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WIRELESS ENGINEER

Editor HUGH S. POCOCK, M.I.E.E. Technical Editor Prof. G. W. O. HOWE, D.Sc., M.I.E.E.

VOL. XXII FEBRUARY, 1945 NO. 257

EDITORIAL

Electromotive Force and Potential Difference

THE potential difference between two points is generally defined as the work done in transferring unit quantity of electricity from one point to the other. The path to be followed is not specified because the work done is assumed to be independent of the path. This assumption is correct in electrostatic or " potential " fields, but where there is a changing magnetic field, and the resulting electric field is a " curl " field, it is no longer true, and the application of the concept of potential difference to such fields leads to difficulties. When one speaks of the p.d. at a given distance along a transmission line, there is no ambiguity with direct current, because the line integral of the electric force between a point on one wire and a point on the other is independent of the path followed, but with alternating current it has to be assumed that the path followed is the shortest distance between the wires, otherwise different values are obtained depending on the path followed. With this general definition of potential difference one thus obtains a value which may or may not represent correctly the difference of electric condition which one associates with the term " potential difference." The ambiguity is removed by specifying that the electric force of which the line integral is taken must be that due to, or associated with, the distribution of electric charges and no other.*

If Fig. 1 (a) represents a core carrying a magnetic flux normal to the paper, round which is situated a copper ring, then, assuming the magnetic flux to be increasing or decreasing, an e.m.f. will be induced in the ring and a current will flow around it, but there will be no p.d. between different points on the ring. One may be tempted to explain this as due to the fall of potential IR being exactly counterbalanced by the induced e.m.f., but this is merely dragging in the concept of potential where it is quite out of place. If instead of a copper ring we had a groove in the table top filled with water and applied a circular water-motive force by means of a fan rotating horizontally just above it, we should have a flow of water around the groove, but no question of difference of level or pressure.

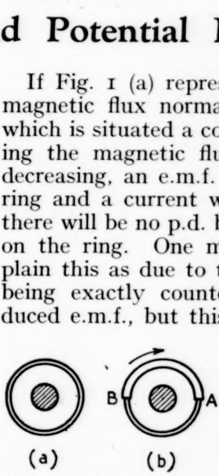

Fig. 1.

If now we replace the copper ring by an ebonite ring is there any difference of potential between, say, diametrically opposite points on the ring? There are line integrals of electric force, an infinite number of them, but nobody would suggest that there is any difference of electrical condition between different parts of the ring. It is as if the water in the groove were replaced by a jelly, which suffers an elastic displacement but is in exactly the same state at every point of the circumference. If the ebonite ring be replaced by a vacuous ring the same is true; an elastic displacement occurs—

---

* In vector notation $\mathcal{E} = -\operatorname{grad}\phi - \frac{1}{c}\frac{\partial A}{\partial t}$ where ϕ is the scalar potential, A the vector potential, and $H = \operatorname{curl} A$. Hence the ordinary scalar potential difference is not equal to the line integral of $\mathcal{E}$ except when A is unchanging.

unless the Maxwellian displacement currents are a myth. That one cannot reasonably talk of the p.d. between the opposite points of the ebonite ring is obvious from the fact that the line integral of the electric force can be positive or negative or even zero if the path be across the diameter.

Going back to the groove filled with water, let us consider what would happen if the cross-section for half the circumference were much smaller than for the other half as in Fig. 1 (b). On starting up the fan and thus applying a water-motive force there would be an increase of head or potential at *A* and a decrease at *B*. Going round the ring there would be a gradual increase of head from *B* to *A* and a corresponding fall of head from *A* to *B*. In the part of large cross-section and therefore of small resistance the pressure due to the difference of head would oppose the water-motive force, whereas in the part of small cross-section it would be in the same direction and assist it. Exactly analogous conditions hold if the electric circuit be made of parts of different resistance per unit length. Some parts will become positively charged and other parts negatively and the resulting electric force at any point will be the resultant of the induced force $\mathcal{E}_i$ due to the changing magnetic field and the force $\mathcal{E}_p$ due to the distribution of the electric charges. Over the high resistance sections of the ring $\mathcal{E}_i$ and $\mathcal{E}_p$ will be additive, whereas over the low resistance sections they will be in opposition. In specifying the potential difference between any two points, the line integral of $\mathcal{E}_p$ must be taken and $\mathcal{E}_i$ ignored. In taking the line integral around the whole circuit, $\mathcal{E}_p$ cancels out whereas $\mathcal{E}_i$ gives the induced e.m.f. If the high resistance portion be replaced by a dielectric or a vacuum, it is analagous to filling half the grooved ring with jelly and leaving water in the other half. There will be such a distribution of water that the back pressure due to the difference of head exactly counterbalances the induced water-motive force at every point in the water which is therefore at rest, whereas in the jelly their combined effect produces the resulting elastic displacement at every point. To make the analogy complete, however, the groove containing the water must not be in the table-top but in a mass of rather stiff jelly, because all the space around the conductor is a dielectric capable of some electric displacement. It is clear from these examples that there need be no ambiguity about potential difference if it be defined as the line integral of the electric force due to the distribution of electric charges. It is then quite independent of the path followed, e.g., in a dynamo the p.d. between its terminals is equal to the line integral of $\mathcal{E}$ whether the path be external to the machine or internal, if in the latter case, one takes only $\mathcal{E}_p$ into consideration and ignores $\mathcal{E}_i$.

In the somewhat analogous case of a magnetic circuit consisting of an iron ring with an air-gap, magnetised by a current-carrying conductor passing through the middle of the ring the electrical engineer determines the reluctance of each part of the circuit and then assumes the total m.m.f. to be distributed accordingly. The dynamo designer calculates the m.m.f. necessary for the air-gap, poles, yoke, armature, etc., and assumes that the total available m.m.f. is automatically distributed between the various parts of the magnetic circuit. Effects of poles and magnetic potential differences are not mentioned. The physicist, however, is more likely to adopt a different procedure or, at least, a different way of looking at the problem. He will probably assume that the m.m.f. is uniformly distributed over the length of the path, as the result of which the iron becomes magnetised and develops poles which tend to demagnetise the iron, since in the iron the magnetising force due to the poles is opposed to the m.m.f., whereas in the air-gap the poles act in the same direction as the m.m.f. One could, however, assume that the whole m.m.f. is applied to the iron part of the circuit ; this would make the poles a little stronger and thus increase the demagnetising force in the iron to counteract the slightly larger m.m.f. per unit length. In the air-gap the slightly stronger poles would increase the field by just enough to make up for the loss of the m.m.f. All three ways of looking at the problem lead to the same ultimate result and the first two certainly appear equally reasonable. They are quite analogous to the two ways of regarding the electric circuit, one neglecting the accumulation of charges and potential differences, and simply assuming the total induced e.m.f. to be automatically distributed around the circuit according to the resistance of each part, the other assuming a uniform distribution of the induced e.m.f. the electric force $\mathcal{E}_i$ due to which is then modified by the electric force $\mathcal{E}_p$ due to the distribution of the charges and the consequent potential differences. The latter is merely a description of the " mechanism " by which the e.m.f. is automatically distributed around the circuit in accordance with the needs of the various parts. It is the necessity of $\mathcal{E}_p$ either just counteracting $\mathcal{E}_i$ at every point in the conductor, or just falling short of doing so by sufficient to drive the current if a current be flowing, that decides the distribution of the charges and therefore the potential differences. Strictly speaking, the magnetic case is only comparable with an electric circuit made up of dielectric material, since there is no magnetic parallel to the electric conductor.

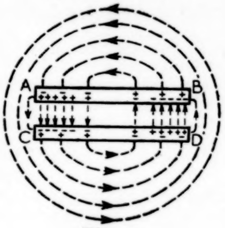

Fig. 2.

If two conductors are situated as shown in Fig. 2 in a steadily changing symmetrical magnetic field normal to the paper, so that the induced e.m.f. causes them to become charged as shown, there will be no current after the initial rush and the resultant electric force $\mathcal{E}$ at every point of the conductor is therefore zero. One could explain the existing condition without any reference to charges or potential difference by saying that the induced e.m.f. is so distributed that there is no part of it operative in the conductors but that it operates entirely in the dielectric separating the two conductors. A more detailed explanation, however, takes into account the electric forces due to the accumulated charges; if one assumes that the induced e.m.f. is distributed between the conductor and the dielectric, then in the former $\mathcal{E}_p$ and $\mathcal{E}_i$ are equal and opposite at every point, whereas in the dielectric they are additive. One might raise the following point: if some of the field of the charge at *A* is directed along *AB* in opposition to $\mathcal{E}_i$, will not the field due to the charge passing across from *A* to *C* be less than $4\pi q$? The answer is yes, from one point of view, but to this must then be added the field due to $\mathcal{E}_i$ which just makes up the deficit, thus making the total field crossing the dielectric exactly equal to $4\pi q$. The electric flux leaving the surface of the conductor must, of course, be equal to the charge on the surface. The potential rises as one goes along the conductor from *B* to *A*, then falls by the same amount from *A* to *C* since *B* and *C* must obviously be at the same potential.

Fig. 3 shows a wave-guide with a H_{01} type of wave, or a simple overhead transmission line. At the moment represented the magnetic flux (not shown but normal to the paper) through the rectangle *ABDC* is zero but is changing at its maximum rate in such a direction that an e.m.f. is induced around the path *BACD*. Should one regard this as acting solely on the conducting walls, and producing potential differences between *A* and *C* and between *B* and *D*, which then produce electric fields, or is it preferable to picture the electric fields being induced by the moving magnetic fields sweeping along the guide and thus inducing the e.m.f. in the dielectric spaces? From the above considerations it is fairly obvious that it is largely a matter of taste, since the various ways of picturing the phenomena are equally valid so long as they give the correct values of the realities, viz., the distribution of charges and currents and the resultant electric and magnetic fields.

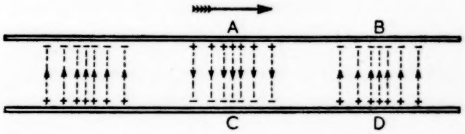

Fig. 3.

G. W. O. H.

SIGNAL/NOISE CHARACTERISTICS OF TRIODE INPUT CIRCUITS*

By R. E. Burgess, B.Sc.

(Radio Division, National Physical Laboratory)

SUMMARY.—The advantages of a high-slope triode amplifying stage at the input of a receiver are described.

The overall equivalent noise resistances for (i) the normal amplifier; (ii) the cathode follower; and (iii) the cathode-input circuit are derived and discussed. Transit-time effects and inter-electrode capacitances are ignored and justification for neglecting the latter is indicated. It is found that for practical purposes the existence of cathode feedback does not affect the contribution of the valve to the noise. The thermal noise arising in the output circuit and the influence of the noise from the following valve are considered and the advantage of preceding a pentode amplifier or a frequency changer by a triode stage is demonstrated.

The loss in signal/noise ratio in an ideal transformer, coupling a signal source to a valve and the condition for minimising this loss are deduced. The minimum loss with an ideal transformer is compared with the loss occurring when the source is connected directly to the valve.

1. Introduction

IN a receiving system the signal/noise ratio which obtains at the aerial is always reduced at later stages due to the introduction of additional circuit and valve noise. Circuit noise between the aerial and first valve could be eliminated by connecting the aerial directly to the valve but unless the aerial is of high resistance (e.g. a λ dipole or a rhombic aerial) the valve noise will result in excessive loss in signal/noise ratio. Thus it is usual to use a tuned circuit as a coupling element to step up the signal voltage and correspondingly to reduce the effect of valve noise although the tuned circuit will itself introduce thermal noise. Even with high resistance aerials, such a coupling circuit may be necessary to provide signal frequency selectivity and to reduce cross modulation.

In some cases it is not possible to obtain a very high dynamic impedance on the input circuit due, say, to an unavoidably small tuning inductance or large reflected resistance from the aerial, or because of bandwidth considerations. The valve noise, and consequently the accurate tuning of the first circuit, then become important and it is necessary to consider the lowest value to which this noise can be reduced.

Frequency changers usually have considerably greater noise than amplifiers, while pentodes have a greater noise than triodes of the same slope on account of the additional fluctuations due to the sharing of the space current between two electrodes. Theoretical formulae for the equivalent noise resistance R_0 of amplifying valves due to the shot effect have been given by Harris[1] and show close agreement with the measured values:

$$\text{Triode } R_0 = \frac{2.5}{g} \text{ kilohms.}$$

$$\text{Pentode } R_0 = \frac{i_a}{i_a + i_s}\left(\frac{2.5}{g} + \frac{20\, i_s}{g^2}\right) \text{ kilohms.}$$

where g = slope in mA/V

i_a = anode current in mA

i_s = screen current in mA.

Thus to take typical values for high-slope valves:

Triode; $g = 8\text{mA/V}$, $R_0 = 310$ ohms.

Pentode; $g = 8\text{mA/V}$, $i_a = 10$ mA,

$i_s = 2.5$ mA, $R_0 = 880$ ohms.

If these same valves were used as mixers with their optimum conversion conductance of 2mA/V, the noise resistances would be approximately 2,000 ohms and 4,000 ohms, for the triode and pentode, respectively. Thus the advantage of the triode amplifier is clearly seen and the object of the present paper is to investigate the signal/noise characteristics of the three common types of triode circuit: (i) normal amplifier; (ii) the cathode follower; and (iii) the cathode-input circuit.

To simplify the analysis, it has been

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* MS. accepted by the Editor, October, 1944.

assumed that the transit-time effects and the inter-electrode capacitances can be ignored. These capacitances would modify the signal/noise characteristics at ultra-high frequencies and lead to undesirable feedback effects which would give rise to either damping of the associated tuned circuit or self-oscillation. For this reason neutralisation is usually necessary in order to eliminate the effect of the particular capacitance causing feedback. The other two inter-electrode capacitances can be included in the impedance of the attached circuits at the input and output.

2. General Circuital Equations

The general circuit considered is shown in Fig. 1 with the following notation :—

μ = amplification factor of valve
g = slope of valve
R_a = internal anode resistance of valve
R_0 = noise resistance of valve
Z = impedance between grid and earth
Z_1 = impedance between cathode and earth
Z_2 = impedance between anode and earth.

As mentioned in the introduction, it is assumed that valve inter-electrode capacitances and transit-time effects are negligible. The equations of the circuit are

$$e_g = e + e_1 - iZ_1$$

$$e_1 + e_2 + \mu e_g = (R_a + Z_1 + Z_2)i$$

and thus

$$i = \frac{\mu e + (\mu + 1)\,e_1 + e_2}{R_a + Z_2 + (\mu + 1)Z_1} \quad \ldots \quad \ldots \quad (1)$$

which gives the anode current i when generators e, e_1, and e_2 are inserted in the grid, cathode and anode circuits, respectively. Thus the input and output impedances and the voltage gain of the amplifier can be deduced.

To calculate the noise output at any two terminals, it is necessary to know the sources of thermal and shot e.m.f. and from the transfer admittances between these noise sources and the output [deduced from equation (1)] the total noise output is found after addition of the squares of the randomly related e.m.fs. If $K = 4kTB$ in the usual notation, the mean square thermal noise e.m.fs. in Z, Z_1, Z_2 are KR, KR_1 and KR_2, respectively. Also the mean square shot noise e.m.f. acting in the anode circuit is $K\mu^2R_0$.

The overall signal/noise characteristics of the amplifier can be conveniently represented by an equivalent noise resistance R_n referred to the input terminals. Thus if the source has resistance R_s while the mean square output noise e.m.f. is V_n^2 and the voltage gain of the amplifier G, we define R_n by the equation.

$$V_n^2 = |G|^2\,K(R_s + R_n) \quad \ldots \quad \ldots \quad (2)$$

or explicitly

$$R_n = \frac{V_n^2}{|G|^2K} - R_s \quad \ldots \quad \ldots \quad (3)$$

The factor by which the signal/noise power ratio has deteriorated is simply

$$|G|^2\frac{KR_s}{V_n} = \frac{R_s}{R_s + R_n} \quad \ldots \quad \ldots \quad (4)$$

and thus the loss in signal/noise ratio due to connecting the amplifier to a signal source of known impedance can be readily computed.

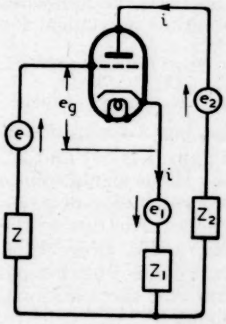

Fig. 1. *The general triode circuit.*

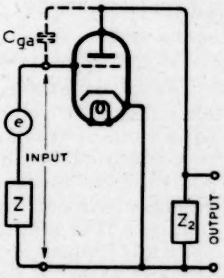

Fig. 2. *The normal amplifier.*

In all the analyses it is assumed that the impedances are substantially constant within the bandwidth B and that they are at a common temperature T.

3. The Normal Amplifier

In this circuit (Fig. 2) the signal is applied between grid and earth and the output is taken off across the anode load Z_2, while the cathode load is assumed to be zero ($Z_1 = 0$). Within the assumptions of the paper, the input impedance is infinite, while the output impedance (to which Z_2 is connected) is R_a. The stage gain is given by the usual expression

$$G = \frac{\mu Z_2}{R_a + Z_2} \quad \ldots \quad \ldots \quad \ldots \quad (5)$$

To compute the signal/noise ratio of the amplifier and thus its equivalent noise resistance, it is necessary to calculate the total noise p.d. appearing at the terminals of Z_2 due to all the sources of noise in the circuit. If we remember that the thermal noise generator KR_2 is internal to Z_2, we find that the mean square noise output is

$$V_n^2 = K \frac{\mu^2(R + R_0)|Z_2|^2 + R_a^2 R_2}{|R_a + Z_2|^2} \quad \ldots \quad \ldots \quad (6)$$

Thus from equations (3), (5) and (6) the equivalent noise resistance of the circuit looking into its input terminals is given by

$$R_n = R_0 + \frac{R_2}{g^2|Z_2|^2} \quad \ldots \quad \ldots \quad (7)$$

The term R_0 is simply due to the valve noise while the second term arises from the thermal noise in Z_2 and is seen to be directly proportional to the conductance $R_2/|Z_2|^2$

In order to illustrate the formulae obtained in this and later Sections the following numerical values will be taken as typical for a high-slope triode :

$\mu = 50$ $\qquad g = 5\text{mA/V}$
$R_a = 10{,}000$ ohms $\qquad R_0 = 500$ ohms.

Thus if the anode load has a resistance of 2,000 ohms the voltage gain G is 8.3 and R_n has a value of 520 ohms. If the signal source (e.g. tuned circuit) has a resistance of 2,000 ohms the loss in signal/noise ratio due to the amplifier is found to be 1.0 db. from equation (4). It is seen that the effect of thermal noise in Z_2, which accounts for the additional 20 ohms in R_n, is negligible.

Now in practice the output load Z_2 is connected to the following valve V which may be a pentode amplifier or a frequency changer, i.e., a valve with a higher noise resistance R'_0 than the triode valve in the first stage. Thus it is useful to know the improvement in signal/noise ratio due to coupling to this second valve *via* a triode amplifier compared with direct connection of the signal source to V [Figs. 5(a), (c)]. The equivalent noise resistance of the amplifier when R_2 is followed by a valve with noise resistance R_0' is simply

$$R_n' = R_n + \frac{R_0'}{|G|^2} \quad \ldots \quad \ldots \quad (7a)$$

and the overall loss in signal/noise ratio is obtained from equation (4) using R_n' in place of R_n. In Fig. 6 the overall loss in signal/noise ratio from the signal source to the anode of V is compared for the cases of direct connection and of triode coupling by means of the amplifier typified above, having a gain of 8.3. The loss is shown as a function of R_0' (the noise resistance of V) and the advantage of the initial triode stage is seen to be pronounced when R_0' is appreciably greater than the 500 ohms of the triode, as it will be if the valve V is, say, a frequency changer.

In the normal triode amplifier the grid-cathode and the anode-cathode capacitances can be considered as being included in Z and Z_2, respectively, and it is the grid-anode capacitance which is responsible for feedback phenomena. The feedback can manifest itself as a positive or negative input conductance, neither of which is desirable since undue damping of the input circuit or self-oscillation is likely to result. Thus for the practical application of the amplifier at radio frequencies, it is usually essential to adopt some form of neutralisation for C_{ga} either in a single-valve or push-pull circuit.

4. The Cathode Follower

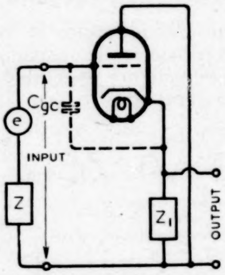

Fig. 3. *The cathode follower.*

In this circuit (Fig. 3) the signal is applied between the grid and earth and the output is taken off between cathode and earth while the anode and earth are joined by a path of zero impedance ($Z_2 = 0$).

The input impedance is high (infinite if valve capacitances are ignored) while the output impedance of the valve is $R_a/(\mu + 1)$ which is very approximately equal to $1/g$. The voltage gain is

$$G = \frac{\mu Z_1}{R_a + (\mu + 1)Z_1} = \frac{gZ_1}{1 + gZ_1} \text{ approx.} \quad \ldots \quad \ldots \quad (8)$$

which is less than unity.

The mean square output noise p.d. across Z_1 is given by

$$V_n^2 = K \frac{|\mu Z_1|^2(R + R_0) + R_a^2 R_1}{|R_a + (\mu + 1)Z_1|^2} \quad \ldots \quad \ldots \quad (9)$$

from which the equivalent noise resistance of the cathode follower is found to be

$$R_n = R_0 + \frac{R_1}{g^2|Z_1|^2} \quad \ldots \quad \ldots \quad (10)$$

Thus the existence of cathode feedback in the cathode follower does not modify the effect of valve noise with respect to signal since R_0 occurs as one term; the thermal noise in the output load (Z_1) enters into R_n in a similar manner to that for the case of the normal amplifier.

Considering the same numerical values as before, it is found that the output impedance is very approximately 200 ohms; if the cathode load is a resistance of 200 ohms, giving a match to the output impedance, the voltage gain is 0.5 and the equivalent noise resistance

$$R_n = 500 + 200 = 700 \text{ ohms.}$$

Thus the thermal noise in the cathode load makes an appreciable contribution to the total noise. If the signal source has a resistive impedance of 2,000 ohms the loss in signal/noise ratio due to the cathode follower is 1.3 db.

In the cathode follower the anode-cathode and anode-grid capacitances can be included in Z_1 and Z, respectively. The grid-cathode capacitance gives rise to feedback effects giving a positive input conductance when Z_1 is inductive and a negative conductance when Z_1 is capacitive, and it will usually be necessary to neutralise for C_{gc} in order to maintain a substantially zero input conductance.

5. The Cathode-Input Amplifier

In the cathode-input (or grounded-grid) amplifier the signal is applied between cathode and earth and the output taken off across the anode load Z_2, the grid being joined to earth by a path of zero impedance (Fig. 4).

The input impedance into which the signal source (e_1, Z_1) operates is given by $(R_a + Z_2)/(\mu + 1)$ which is usually a low resistive impedance of the order of $1/g$. The output impedance of the valve is given by $R_a + (\mu + 1)Z_1$. The voltage gain is

$$G = \frac{(\mu + 1)Z_2}{R_a + Z_2 + (\mu + 1)Z_1} \qquad \ldots \quad (11)$$

The mean square noise p.d. across Z_2 is

$$V_n^2 = K\frac{(\mu + 1)^2 R_1 |Z_2|^2 + \mu^2 R_0 |Z_2|^2 + |R_a + (\mu + 1)Z_1|^2 R_2}{|R_a + Z_2 + (\mu + 1)Z_1|^2} \qquad \ldots \quad \ldots \quad \ldots \quad (12)$$

and thus the equivalent noise resistance is given by

$$R_n = \left(\frac{\mu}{\mu + 1}\right)^2 R_0 + \left|\frac{R_a + (\mu + 1)Z_1}{(\mu + 1)Z_2}\right|^2 R_2 \qquad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (13)$$

It is seen that the valve noise is for all practical purposes unaffected by the feedback for the factor $[\mu/(\mu + 1)]^2$ is usually very close to unity.

Taking the same valve parameters as before and an anode load resistance of 2000 ohms it is found that the input impedance is 235 ohms. Thus if the impedance of the source is 200 ohms the output impedance is 20,200 ohms, the voltage gain 4.6, and the equivalent noise resistance

$$R_n = 480 + 80 = 560 \text{ ohms.}$$

The loss in signal/noise ratio is then 5.8 db.

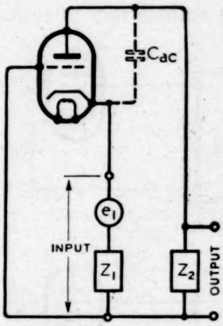

Fig. 4. *The cathode-input amplifier (or grounded-grid circuit).*

The chief use of the cathode-input amplifier is to couple a low-impedance source (e.g. a transmission line) to a high impedance, and it is of interest to compare the relative performances of this amplifier and of the ideal transformer having optimum coupling taking into account the noise introduced by the following valve. The signal/noise characteristics of the ideal transformer coupling a source R to a sink R_2 connected to a valve V with noise resistance R_0' are analysed in the next Section. The optimum coupling for maximum signal/noise ratio is found and the loss in this condition is a function of the ratio R_0'/R_2 (upper curve in Fig. 8).

In Fig. 7 the loss in signal/noise ratio for the cathode-input amplifier, for the optimum ideal transformer and for direct connection are shown as a function of R_0' with $R_1 = 200$ ohms and $R_2 = 2000$ ohms. It is seen that the ideal transformer is better than the direct connection while for R_0' greater than 1200 ohms the cathode-input amplifier is better than either. Thus when the source is of low impedance, the relative merits of the triode amplifier and the transformer are mainly determined by the nature of the following valve V.

The component of inter-electrode capacitance which causes feedback in the cathode-input circuit is C_{ac} but the necessity for neutralisation does not seem to be so stringent as in the two previous triode circuits.

6. Loss in S/N ratio due to an Ideal Transformer

The problem considered is shown in Fig. 5. A signal source of e.m.f. e and resistive impedance R is coupled to the load impedance R_2 by an ideal transformer of ratio $1 : n$ and is followed by a valve V of noise resistance R_0'. It is required to know the loss in signal/noise ratio due to the system when the coupling is optimum.

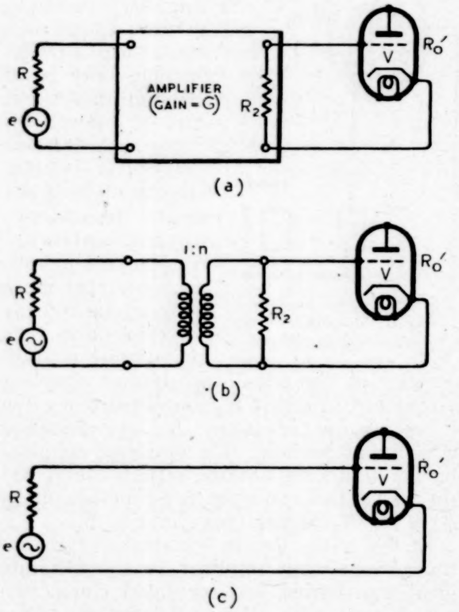

Fig. 5. *Coupling by* (a) *an amplifier,* (b) *an ideal transformer, and* (c) *direct connection.*

The signal p.d. across R_2 is given by

$$V_s = e\frac{nR_2}{n^2R + R_2}$$

and the total effective noise resistance at the grid of V is

$$\frac{n^2RR_2}{n^2R + R_2} + R_0'$$

and thus the equivalent noise resistance of the whole circuit at the input terminals is :—

$$R_n' = \left(\frac{e}{V_s}\right)^2\left[\frac{n^2RR_2}{n^2R + R_2} + R_0'\right] - R$$
$$= \frac{R}{R_2}\left[N(R_0' + R_2) + 2R_0' + \frac{R_0'}{N}\right]$$

where $N = \dfrac{n^2R}{R_2}$

Thus R_n' is a minimum when

$$N_{\text{opt.}} = \sqrt{\frac{R_0'}{R_0' + R_2}}$$

which is always less than unity, the value giving maximum signal. In the optimum condition, R_n' reaches its minimum value of

$$R'_{n\,\text{min.}} = \frac{2R}{R_2}\left(R_0' + \sqrt{R_0'(R_0' + R_2)}\right)$$

The loss in signal/noise ratio in this optimum condition is given by

$$\sqrt{\frac{R}{R + R'_{n\,\text{min.}}}} = \frac{\sqrt{R_0' + R_2} - \sqrt{R_0'}}{\sqrt{R_2}}$$

which is simply a function of the ratio R_0'/R_2. In practical radio-frequency transformers the resistance R_2 corresponds to the dynamic impedance of the tuned secondary with the aerial not connected to the primary.

It is clear that when the resistance R of the source exceeds a certain value it is better to connect it directly to the valve V than through the transformer. The criterion for these two methods of connection will now be considered.

Let $x = R_0'/R_2$ and $y = R_0'/R$ then the loss in signal/noise ratio for direct connection of the source to the valve is $1/\sqrt{1 + y}$ and that for coupling by the optimum ideal transformer is $(\sqrt{1 + x} - \sqrt{x})$. These losses

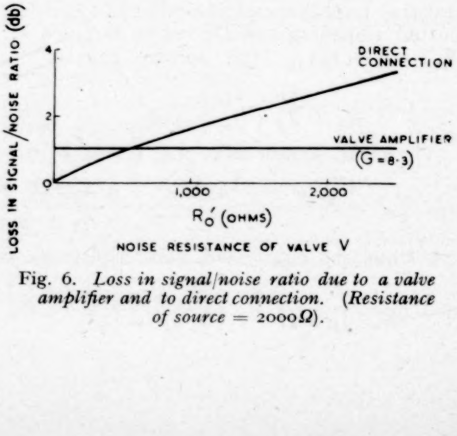

Fig. 6. *Loss in signal/noise ratio due to a valve amplifier and to direct connection.* (*Resistance of source* = 2000Ω).

are plotted in Fig. 8 as functions of x and y and their comparison enables the choice of the better method of connection to be made. If the noise resistance R_0' of the valve V be known and R_2 is the value of dynamic impedance which can be obtained in a tuned grid circuit, x is determined and with it the loss for optimum transformer coupling. The value of y and thus of R which gives the same loss is then found ; if now the resistance of the source exceeds this value of R direct connection is better than the transformer coupling, while if it is less the reverse is true.

The relation between x and y for equal loss in signal/noise ratio is

$$y = 2\sqrt{x}(\sqrt{x} + \sqrt{x+1}) > 4x$$

in other words, for a given R_0' the value of R_2 which leads to a certain loss in the transformer connection is always greater than four times the value of R which gives the same loss for direct connection.

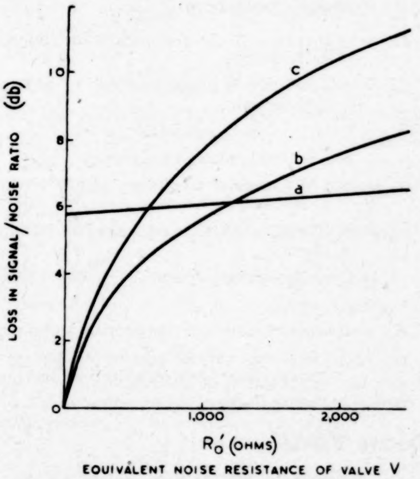

Fig. 7. *Comparison of* (a) *the cathode-input amplifier,* (b) *the ideal transformer with optimum coupling, and* (c) *direct connection of source to valve* V. ($R = 200\,\Omega, R_2 = 2000\,\Omega, G = 4.6$).

The simple theory for the ideal transformer holds to a close approximation for a practical transformer having coupling sufficiently close for the optimum condition to be realised when the source is resistive.

7. Conclusions

The results of the earlier sections can now be summarised as follows :

(i) The contribution of valve noise to the equivalent noise resistance of the whole amplifier is R_0 for the normal amplifier and cathode follower and

$$\left(\frac{\mu}{\mu + 1}\right)^2 R_0$$

for the cathode-input circuit. Thus one may say that the valve noise is substantially the same for all the circuits considered.

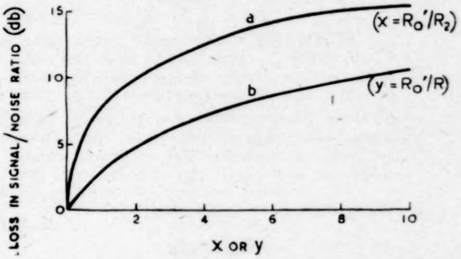

Fig. 8. *Loss in signal/noise ratio due to* (a) *connection through the optimum ideal transformer, and* (b) *direct connection.*

(ii) The thermal noise arising in the output circuit (R_2 or R_1) contributes to R_n to a significant extent, and cannot usually be neglected.

(iii) Coupling a source R to a valve of noise resistance R_0' by the optimum ideal transformer will always be inferior to direct connection if the dynamic impedance R_2 of the secondary is less than four times the resistance R of the source.

(iv) The triode amplifier is superior to both the ideal transformer and direct connection when the following valve has a noise resistance above a certain value (compare intersection points in Figs. 6 and 7).

8. Acknowledgments

The work described above was carried out as part of the programme of the Radio Research Board, to whom this paper was first circulated in December 1942. It is now published by permission of the Department of Scientific and Industrial Research.

REFERENCES

[1] W. A. Harris. " Fluctuations in Space-Charge-Limited Currents at Moderately High Frequencies, Part V—Fluctuations in Vacuum Tube Amplifiers and Input Systems." *R.C.A. Review*, **1941**, Vol. 5, pp. 505–524.

Reference may also be made to two useful papers which have appeared since the present paper was written.

[2] C. E. Lockhart. " The Cathode Follower. Part IIIa. Noise Performance." *Electronic Engineering*, **1943**, Vol. 16, pp. 21–23.

[3] M. Dishal. " Theoretical Gain and Signal-to-Noise Ratio of the Grounded-Grid Amplifier at Ultra-High Frequencies." *Proc. I.R.E.*, **1944**, Vol. 32, pp. 276–284.

INSERTION LOSS OF FILTERS[*]

Half- and Single-Section, Low-, High- and Symmetrical Band-Pass, With or Without Dissipation, Terminated by the Design Resistance

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SUMMARY.—This paper gives some considerable extensions to a previous paper by C. W. Miller.[†] It is shown that the same insertion loss formulas apply to non-dissipative filters of low-, high- and symmetrical band-pass types, and expressions are derived for the insertion loss at any frequency and at "cut-off" of half- and single-section filters terminated in their design resistance, $\sqrt{L_K/C_K}$. The effect of dissipation in the inductors in half and whole sections is considered for three cases, as follows: (*a*) peak insertion loss of all derived sections, (*b*) insertion loss at design cut-off of all types of section, and (*c*) insertion loss at midband, and pass-band distortion, of band-pass sections.

The detailed working is not given, in the interests of brevity, but any approximations made have been indicated.

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Whole section Type B Networks (series-derived π and shunt-derived *T*).
Half-section networks of either type.
3. The insertion loss at the cut-off frequency.

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2. The effect of dissipation on the insertion loss at the attenuation peak.
3. The effect of dissipation on the insertion loss at the cut-off frequency.
4. The midband insertion loss of a dissipative band-pass half or whole section.
5. Passband "distortion" of band-pass filters.
6. An example of practical responses.
Conclusions.
Bibliography.

Symbols Used

R = design resistance = $\sqrt{\frac{L_K}{C_K}}$

L_K = inductance of prototype low- or high-pass half-section.

C_K = capacitance of prototype low- or high-pass half-section.

m = "derivation" parameter.

n = bandwidth/midband frequency.

ω_c = cut-off[§] angular frequency of low- or high-pass filter.

ω_0 = midband angular frequency of bandpass filter.

Correspondingly f_c and f_0.

x = f/f_c or f/f_0

K = frequency function (see Section 1 of paper).

ω_∞, x_∞, K_∞ are values corresponding to the attenuation peak of a derived section.

Q = "quality factor" of an inductor.

Part I. Non-Dissipative Filters

In a paper appearing in the January, 1944, issue of *Wireless Engineer*, C. W. Miller gave an analysis of single-section low- and high-pass filters, deriving expressions for their insertion loss between source and load resistances equal to their "design resistance" $R = \sqrt{\frac{L_K}{C_K}}$.[‡] Certain extensions to Miller's paper can be made very simply.

1. Extension to Band-Pass Filters

Fig. 1 shows half-sections of band-pass filter of the "six-element" symmetrical type, i.e. of the type where the performance at a frequency xf_0 is the same as at $\frac{1}{x}f_0$ (except for the opposite sign of the phase-shift), where f_0 is the midband frequency.

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[*] MS. accepted by the Editor, October 1944.

[†] C. W. Miller, "Single-Section *m*-Derived Filters," *Wireless Engineer*, Vol. 21, p. 4 (Jan. 1944).

[§] Throughout this paper, "cut off" means the design cut-off, i.e. the frequency at which the *image* transfer coefficient is discontinuous.

[‡] The terminology is defined in Miller's paper, which should also be referred to for particulars of the methods by which filter sections are built up. Alternatively the works listed in the Bibliography may be referred to.

Fig. 2 shows alternative but exactly equivalent reactance arms which often offer important constructional advantages over those of Fig. 1. The exact equivalence generally applies only when any resistance components of the impedance are neglected.

The parameter n is the proportional bandwidth,

i.e. $n = x_2 - x_1$

where $x_1 f_0$ is the lower cut-off frequency

and $x_2 f_0$ is the upper cut-off frequency.

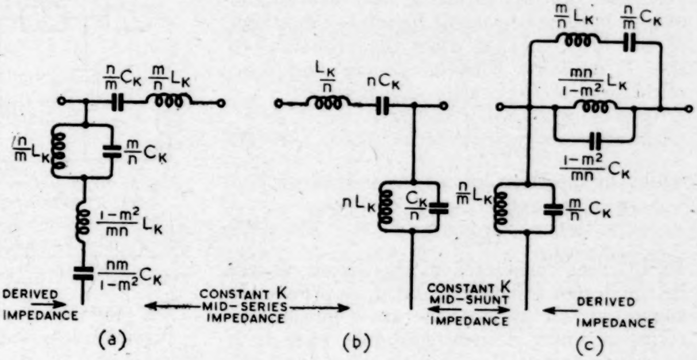

$\frac{n}{m}C_K$
$\frac{m}{n}L_K$
$\frac{n}{m}L_K$
$\frac{m}{n}C_K$
$\frac{1-m^2}{mn}L_K$
$\frac{nm}{1-m^2}C_K$
DERIVED IMPEDANCE
CONSTANT K MID-SERIES IMPEDANCE
(a)
$\frac{L_K}{n}$
nC_K
nL_K
$\frac{C_K}{n}$
(b)
CONSTANT K MID-SHUNT IMPEDANCE
$\frac{m}{n}L_K$
$\frac{n}{m}C_K$
$\frac{mn}{1-m^2}L_K$
$\frac{1-m^2}{mn}C_K$
$\frac{n}{m}L_K$
$\frac{m}{n}C_K$
DERIVED IMPEDANCE
(c)

Fig. 1. *Symmetrical type band-pass half sections.* (a) *Series-derived ;* (b) *Constant-K ;* (c) *Shunt-derived.*

Comparing these with the low- and high-pass types shown by Miller in Fig. 2 of his paper, it is readily seen that the impedance of shunt or series branches of the bandpass filters is exactly

$$\frac{1}{n}\left(1 - \frac{f_0^2}{f^2}\right) = \frac{1}{n}\left(1 - \frac{1}{x^2}\right)$$

times the impedance of the corresponding branch of the low-pass filter. Thus if

Miller's variable K is stated thus :—

$$K = \frac{f}{f_c} = x \text{ for low-pass filters}$$

$$(f_c = \text{cut-off frequency})$$

$$K = -\frac{f_c}{f} = -\frac{1}{x} \text{ for high-pass filters}$$

and $K = \frac{1}{n}\left(x - \frac{1}{x}\right)$ for symmetrical band-pass filters, $(x = f/f_0)$ then *all Miller's formulas apply equally to symmetrical band-pass filters.**

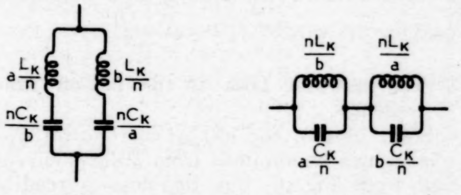

$a\frac{L_K}{n}$
$b\frac{L_K}{n}$
$\frac{nC_K}{b}$
$\frac{nC_K}{a}$
(a)
$\frac{nL_K}{b}$
$\frac{nL_K}{a}$
$a\frac{C_K}{n}$
$b\frac{C_K}{n}$
(b)

Fig. 2. *Alternative form of reactance arms of band-pass derived sections.* (a) *Series-derived shunt arm ;* (b) *Shunt-derived series arm ;*

$$a = \frac{\left(1 - m^2\right)\left(\frac{1}{x_\infty^2} - x_\infty^2\right)}{\sqrt{(x_1{}^2 - x_\infty^2)\,(x_2{}^2 - x_\infty^2)}}\ ; \quad b = ax_\infty^2\ ;$$

$$\frac{1}{n}\left(x_\infty - \frac{1}{x_\infty}\right) = \frac{1}{\sqrt{1 - m^2}}\ ;$$

$x_\infty f_0$ = *frequency of lower attenuation peak ;* $x_1 f_0$ = *lower cut-off frequency ;* $x_2 f_0$ = *upper cut-off frequency.*

It should be noted that by using the frequency function K, it is possible (and much more convenient) to consider the filters in terms of the impedances of the arms, rather than in terms of the actual components. Fig. 3 shows the basic half sections expressed in this way. Since the design resistance appears as a linear multiplier in every impedance term, it is convenient to take it as unity. This does not affect any of the insertion loss expressions, which are evidently independent of the design resistance.

To determine the insertion loss of half-section filters is evidently now very simple. It is important to notice that the insertion loss is not affected by the direction of transmission through the half section. To

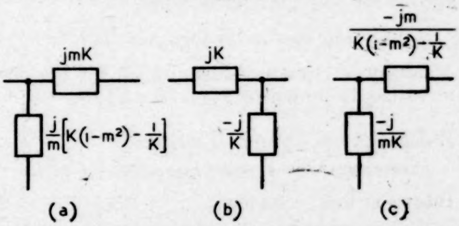

jmK
$\frac{j}{m}\left[K(1-m^2) - \frac{1}{K}\right]$
(a)
jK
$\frac{-j}{K}$
(b)
$\frac{-jm}{K(1-m^2) - \frac{1}{K}}$
$\frac{-j}{mK}$
(c)

Fig. 3. *Low-, high-, and symmetrical band-pass half-section impedances (non-dissipative, design resistance*$=1$). (a) *Series-derived :* (b) *constant-K ;* (c) *Shunt-derived.*

---

* Although band-stop filters are not considered in this paper, it is worth pointing out that if we put $K = -n \Big/ \left(x - \frac{1}{x}\right)$ for symmetrical band-stop filters, then the formulas apply to band-stop filters also.

determine the insertion loss of whole sections, it is useful to work in terms of the general T and π networks, as shown in Figs. 4 and 5. The insertion loss ratio (i.e. the ratio of the output voltage or current before the insertion of the filter to that after the insertion) of the T network between source and load resistances of R is easily shown to be

$$\frac{(R + Z_1)\,(R + Z_1 + 2Z_2)}{2RZ_2} \quad .. \quad (1)$$

while the insertion loss of the π network is

$$\frac{(R + Z_2)\,(RZ_1 + Z_1Z_2 + 2RZ_2)}{2RZ_2^2} \quad (2)$$

In all cases considered in this paper, R will be the design resistance, and if, as previously suggested, all impedances are expressed in terms of unity design resistance, then it is necessary to put $R = 1$ in the above expressions.

The use of the methods suggested above simplify the determination of the filter insertion loss formulas.

2. Simplification of Insertion Loss Formulas

Miller left his relations in the form :—

Insertion voltage or current ratio $= X \pm jY$ and insertion loss $= 20 \log_{10}\sqrt{X^2 + Y^2}$ decibels.

Actually if the values of X and Y are substituted directly into the insertion loss formulas, quite simple expressions are obtained in most cases.
Thus :—

Whole Section Type A Networks

(Series-derived T and Shunt-derived π)

Insertion loss*

$$= 20 \log_{10}\sqrt{1 + \left[\frac{mK^3}{1 - (1 - m^2)K^2}\right]^2} \quad .. \quad .. \quad (3)$$

and so for constant-K sections,

$$\text{insertion loss} = 20 \log_{10}\sqrt{1 + K^6} \quad (4)$$

A family of curves of formula (3) for various m values is shown in Figs. 6a and 6b.

Whole-Section Type B Networks

(Series-derived π and Shunt-derived T)

Insertion loss $= 20 \log_{10}$

$$\sqrt{1 + \left[\frac{mK^3}{1 - (1 - m^2)K^2}\right]^2 \left[\frac{1 - (1 - m^2)\{4m^2 + 2K^2(1 - m^2)(1 - 2m^2) - K^4(1 - m^2)^3\}}{[1 - (1 - m^2)K^2]^2}\right]} \quad .. \quad .. \quad (5)$$

This is not a simple expression, unfortunately, but shows the contrast with (3) quite well.

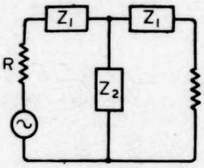


Fig. 4. *General T-network. Insertion loss ratio =* $\frac{(R+Z_1)(R+Z_1+2Z_2)}{2RZ_2}$

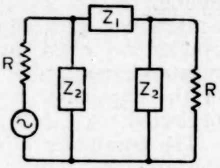


Fig. 5. *General π network. Insertion loss ratio =* $\frac{(R+Z_2)(RZ_1+Z_1Z_2+2RZ_2)}{2RZ_2^2}$

For constant-K sections,

Insertion loss $= 20 \log_{10}\sqrt{1 + K^6}$ as equation (4).

Half-section Networks of Either Type

Insertion loss

$$= 20 \log_{10}\sqrt{1 + \frac{m^2K^4[m^2 + (1 - m^2)^2K^2]}{4[1 - (1 - m^2)K^2]^2}} \quad .. \quad .. \quad (6)$$

and so for constant-K half-sections,

$$\text{Insertion loss} = 20 \log_{10}\sqrt{1 + K^4/4} \quad (7)$$

Note that for all these filters, the attenuation peak occurs when $K^2 = \dfrac{1}{1 - m^2}$.

3. The Insertion Loss at the Cut-off Frequency

Some idea of the loss at the cut-off frequency can be obtained from Miller's curves and from Fig. 6, but this loss is readily expressed by simple formulas derived by substituting $K = 1$ in (3) to (7) above. Thus :—

Whole Section Type A Networks

$$\text{Loss at cut-off} = 20 \log_{10}\sqrt{1 + \frac{1}{m^2}} \quad (8)$$

which is 3 db. for $m = 1$ (constant-K)
and 5.8 db. for $m = 0.6$

---

* If the generator and load resistances are bR instead of R, then equation (3) becomes

$$\text{Insertion loss} = 20 \log_{10}\sqrt{1 + \left[\frac{mK(K^2 - 1 + b^2)}{b\{1 - (1 - m^2)K^2\}}\right]^2}$$

Whole Section Type B Networks

$$\text{Loss at cut-off} = 20 \log_{10}\sqrt{1 + m^2} \qquad (9)$$

which is 3 db. for $m = 1$
and 1.3 db. for $m = 0.6$

Half-section Networks

$$\text{Loss at cut-off} = 20 \log_{10}\sqrt{\frac{1 + 3m^2 + m^4}{4m^2}} \quad \ldots \quad \ldots \quad (10)$$

which is 1 db. for $m = 1$
and 3.7 db. for $m = 0.6$.

The reason for the differences between Type A and Type B network losses is, of course, that Type A presents a constant-K impedance to the terminations, whilst Type B presents a derived impedance. Type B gives a loss at cut-off diminishing as m diminishes, and does not have a minimum loss at $m = 0.6$ as might be expected from Miller's statement that the minimum "rounding" at cut-off is obtained with $m = 0.6$. It is a fact that the derived image impedance of the derived section with $m = 0.6$ is the most constant over the pass-range, and this accounts for the good pass-band characteristic of the $m = 0.6$ Type B section. But the image impedances are in any case discontinous at cut-off, and therefore the insertion loss at cut-off is not necessarily an indication of the rounding-off of the pass-band response.

Part II. The Effects of Dissipation in the Inductors of the Filter

1. Introduction

For some purposes the non-dissipative formulas given in Part 1 are sufficiently representative of the actual performances of the filter. But in practice the inductors will have a resistance which is often by no means negligible. It is generally reasonable to neglect the resistance of the capacitors, and therefore some simple formulas will now be

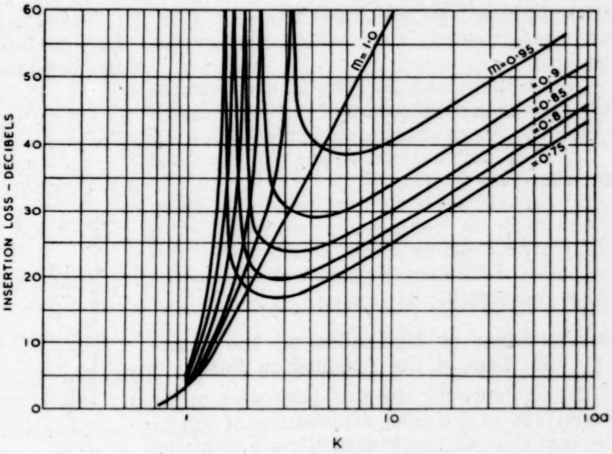


Fig. 6a (Above). *Filter insertion loss. Series-derived T and shunt-derived π, whole section, m from 1.0 to 0.75.*

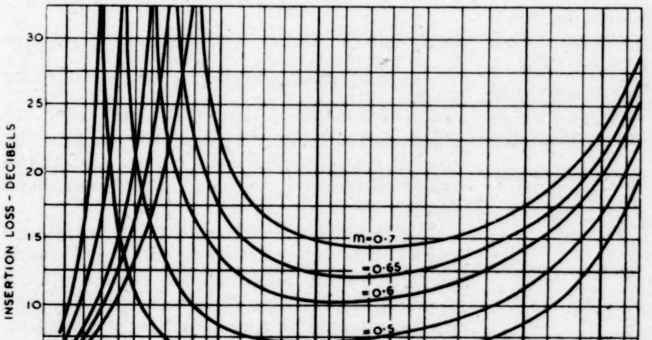


Fig. 6b (Left). *Filter insertion loss, series-derived T and shunt-derived π, whole section, m from 0.7 to 0.4. The K scale is a tangent scale, for convenience only.*

developed which will enable the performance of a filter with dissipative inductors but non-dissipative capacitors to be closely estimated. The procedure followed is to determine the insertion loss at the following critical frequencies, which are chosen because, as special cases, they allow of simpler analysis :—

(a) the frequency of peak attenuation (in the case of derived sections)

(b) the design cut-off frequency, and

(c) the midband frequency (in the case of band-pass filters).

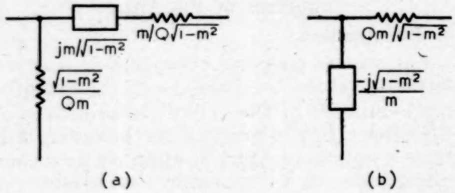


Fig. 7. *Low-pass dissipative half-section impedances at the peak frequency.* (a) *Series-derived ;* (b) *Shunt-derived.*

A consideration of the losses at these frequencies in conjunction with the non-dissipative response should enable the overall response of dissipative filters to be estimated with considerable accuracy.

2. The Effect of Dissipation on the Insertion Loss at the Attenuation Peak

Miller shows the effect of dissipation in the inductors on the peak attenuation of single-section low- and high-pass filters terminated in *image* impedances. But the actual practical magnitude of this peak is the important feature in design, and it is desirable to know the insertion loss (between design resistances $\sqrt{L_K/C_K}$) at the peak for a given Q value. For whole section low- and high-pass filters the peak insertion loss is, for Type A sections, rather lower than the image attenuation shown by Miller in his Curve 4, and in the case of Type B sections it is considerably higher. But the peak loss of a band-pass filter is, as a rule, very much lower than these values, and varies with bandwidth.

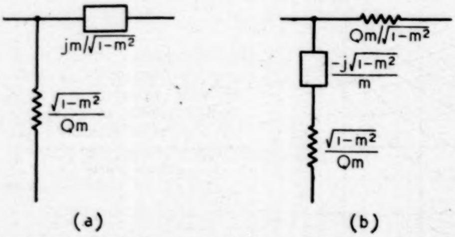


Fig. 8. *High-pass dissipative half-section impedances at the peak frequency.* (a) *Series-derived ;* (b) *Shunt-derived.*

The peak insertion loss (not to be confused with the maximum insertion loss which occurs at zero or infinite frequency) is most readily determined from a consideration of the filter impedances as shown in Figs. 7, 8 and 9 for low-, high-, and band-pass filters respectively. These figures show the filter half sections in terms of the impedances at the peak ; the reactances are determined by substituting $K^2 = \frac{1}{1 - m^2}$ i.e. $K = \frac{\pm 1}{\sqrt{1 - m^2}}$ ($+$ sign for low- and band-pass, $-$ sign for high-pass) in the expressions of Fig. 3, while the resistance terms are obtained from the inductances alone, by putting resistance $= \frac{\omega L}{Q}$ for series resonance or $= Q\omega L$ for shunt resonance. The Q values used are those measured at the peak frequency in the case of low- and high-pass filters, and at the midband frequency in the case of band-pass filters.

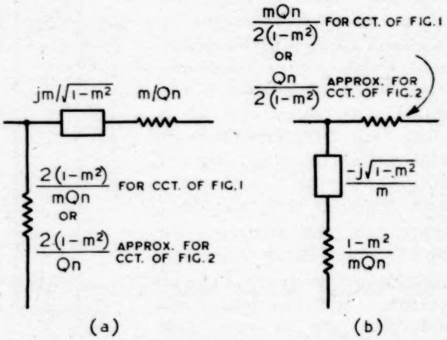

jm/√1−m²
m/Qn
2(1−m²) / mQn FOR CCT. OF FIG. 1
OR
2(1−m²) / Qn APPROX. FOR CCT. OF FIG. 2
(a)
mQn / 2(1−m²) FOR CCT. OF FIG. 1
OR
Qn / 2(1−m²) APPROX. FOR CCT. OF FIG. 2
−j√1−m² / m
1−m² / mQn
(b)

Fig. 9. *Band-pass dissipative half-section impedances at the peak frequency.* (a) *Series-derived ;* (b) *Shunt-derived.*

For the whole-section cases, the impedance values can be substituted in equations 1 and 2 to obtain the insertion loss, and suitable approximations may then be made to obtain the expressions in a sufficiently simple form. Alternatively the networks may be considered as two potentiometers in tandem, and the main approximations made are then that the resistance of non-resonant reactances is negligible, and that the generator resistance is negligible compared with the resonant impedance of the parallel tuned circuits. All approximations made are equivalent to saying that $Q \gg 1$ for low- and high-pass or $Qn \gg 1$ for band-pass filters. Thus the results are accurate (within a decibel or two) for Q or Qn values above say 10. The losses in the approximate forms are identical for low- and high-pass filters. It is also assumed that the band-pass filters do not have a very wide band, so that the resistances do not vary from one peak to the other.

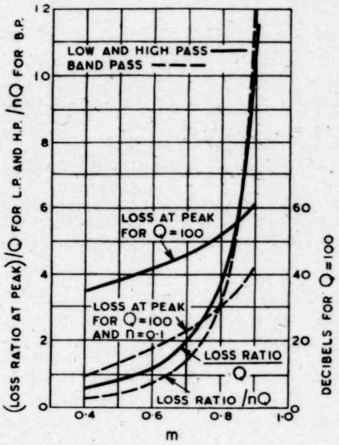


Fig. 10. *Peak insertion loss of series-derived T and shunt-derived π, whole sections.*

The formulas for all half- and whole-section filters are summarised in Table I.

The variation of peak insertion loss with m is shown for low-, high- and band-pass whole sections of series-derived T and shunt-derived π types in Fig. 10. The generalised case, and also a typical case with $Q = 100$, are shown.

The derivation of the expression for the resistance of the shunt arm of the band-pass series-derived half-section, and of the series arm of the shunt-derived half-section, may not be immediately clear, and is therefore given below :—

Considering first the shunt arm of Fig. 1(a) :—

The shunt arm consists of a parallel-tuned circuit and a series-tuned circuit, both resonating at midband. The impedance of the former at any frequency x times midband is

$$\frac{Q\omega_0 n L_K}{m} \cdot \frac{1 + jQ\left(\frac{1}{x} - x\right)}{1 + Q^2\left(\frac{1}{x} - x\right)^2}$$

assuming the effective shunt resistance does not change with frequency.

TABLE I

INSERTION LOSS AT PEAK FREQUENCY

(expressed as a voltage ratio)

WHOLE SECTIONS			
Low- and High-pass	Series-derived T Shunt-derived π	$\frac{Qm}{(1 - m^2)^{3/2}}$	
	Series-derived π Shunt-derived T	$\frac{Q^2m^3}{(1 - m^2)^{3/2}}$	
Band-pass		as Fig. 1	as Fig. 2
	Series-derived T Shunt-derived π	$\frac{mQn}{2(1 - m^2)^2}$	$\frac{Qn}{2(1 - m^2)^2}$
	Series-derived π Shunt-derived T	$\frac{m^3Q^2n^2}{4(1 - m^2)^{5/2}}$	$\frac{mQ^2n^2}{4(1 - m^2)^{5/2}}$
HALF SECTIONS			
Low- and High-pass.—All types		$\frac{Qm}{2(1 - m^2)}$	
Band-pass.—All types		as Fig. 1	as Fig. 2
		$\frac{mQn}{4(1 - m^2)^{3/2}}$	$\frac{Qn}{4(1 - m^2)^{3/2}}$

Putting $L_K = \dfrac{R}{\omega_0}$ and $x - \dfrac{1}{x} = Kn$, this is

$$\frac{QnR}{m} \cdot \frac{1 - jQnK}{1 + Q^2n^2K^2}$$

The impedance of the series tuned circuit is, on making the same substitutions,

$$\frac{R(1 - m^2)}{m}\left(\frac{1}{Qn} + jK\right)$$

$\therefore$ the series resistance at the compound series resonance (i.e. peak frequency) is

$$\frac{QnR}{m(1 + Q^2n^2K_\infty{}^2)} + \frac{R(1 - m^2)}{mQn}$$

and remembering that $K_\infty{}^2 = 1/1\text{–}m^2$, and if $Q^2n^2K_\infty{}^2 \gg 1$, this resistance $= \dfrac{2R(1 - m^2)}{mQn}$.

Considering next the shunt arm of Fig. 2(a) :—

This alternative form of the shunt arm, consisting of two series resonant circuits, resonating at the peak frequencies, gives a slightly different result. The value of the inductance for the lower attenuation peak is

$$\frac{(1 - m^2)\left(\dfrac{1}{x_\infty{}^2} - x_\infty{}^2\right)}{\sqrt{(x_1{}^2 - x_\infty{}^2)\,(x_2{}^2 - x_\infty{}^2)}} \cdot \frac{L_K}{n}$$

Where x_1 and x_2 are the lower and upper cut-off frequencies relative to midband.

$\doteqdot \dfrac{2(1 - m^2)R}{n\omega_0}$ if the bandwidth is not too great.

Therefore the resistance of the shunt arm at the peak

$\doteqdot \dfrac{2R(1 - m^2)}{Qn}$ (assuming a small bandwidth).

The series arm of the shunt-derived filter may be considered in a similar manner.

3. The Effect of Dissipation on the Insertion Loss at the Cut-off Frequency

In this case it is not possible to consider such simple circuits as were used for the peak loss, because at cut-off none of the impedance elements becomes non-reactive. The best plan is to obtain the general

TABLE II

INSERTION LOSS AT CUT-OFF FREQUENCY

(expressed as a voltage ratio)

WHOLE SECTIONS

Low- and high-pass	L.P. Series-derived T H.P. Shunt-derived π	$\sqrt{1 + \frac{1}{m^2} + \frac{2}{Qm}\left(2 + \frac{1}{m^2}\right)}$
	L.P. Shunt-derived π H.P. Series-derived T	$\sqrt{1 + \frac{1}{m^2} + \frac{2}{Qm}\left(1 + \frac{1}{m^2}\right)}$
	L.P. Series-derived π H.P. Shunt-derived T	$\sqrt{1 + m^2 + \frac{2}{Qm}\left(\frac{1}{m^2} + 2 - m^2\right)}$
	L.P. Shunt-derived T H.P. Series-derived π	$\sqrt{1 + m^2 + \frac{2}{Qm}\left(2 + \frac{1}{m^2}\right)}$
Band-pass	Series-derived T Shunt-derived π	$\sqrt{1 + \frac{1}{m^2} + \frac{2}{mQn}\left(3 + \frac{2}{m^2}\right)}$
	Series-derived π Shunt-derived T	$\sqrt{1 + m^2 + \frac{2}{mQn}\left(\frac{2}{m^2} + 4 - m^2\right)}$

HALF SECTIONS

Low- and high-pass	L.P. Series-derived L.P. Shunt-derived	$\sqrt{\frac{1 + 3m^2 + m^4 + (2/Q)\,(2/m + m^3)}{4m^2}}$
	L.P. Shunt-derived H.P. Series-derived	$\sqrt{\frac{1 + 3m^2 + m^4 + (2/Q)\,(2/m + m)}{4m^2}}$
Band-pass	Series-derived Shunt-derived	$\sqrt{\frac{1 + 3m^2 + m^4 + (2/Qn)(4/m + m + m^3)}{4m^2}}$

equation for insertion loss, using equations (1) and (2), and including the resistance of the various inductors, and then to put $K = 1$. This gives the exact insertion loss at cut-off. In this form the expressions are different for every type of filter. But if the expressions are simplified by neglecting terms with Q^2 in the denominator in comparison with terms with only Q or lower powers in the denominator (assuming the expressions are suitably arranged—and in every case only after the modulus has been obtained, for the squaring process introduces new terms which cannot be neglected), then the approximate formulas occur in pairs. The whole series of approximate formulas is given in Table II. It will be observed that there is a certain relation among these. The dissipative term of the band-pass filter of any type is the sum of the dissipative terms of the corresponding low- and high-pass filters, with Q replaced by Qn. If we put $Q = \infty$, we obtain the non-dissipative formulas of equations 8, 9 and 10.

The expressions given are not accurate for Q or Qn values below about 10. To show the order of inaccuracy for lower values, a number of much more exact expressions for the complex insertion loss ratio at cut-off are given below.

Whole sections :—

(a) Low-pass series-derived T :—

$$\frac{\left(1+\frac{1}{Q}\right)^2+\frac{(1-m)^2}{mQ}+j\left(m+\frac{1}{Q}\right)}{\frac{1-m^2}{mQ}-jm}$$

(b) High-pass series-derived T :—

$$\frac{1+\frac{1}{mQ}-j\left(m+\frac{1}{Q}\right)}{\frac{1}{mQ}+jm}$$

(c) Band-pass series-derived T :—

$$\frac{1+\frac{m}{Qn}+\frac{2}{mQn}+\frac{2}{Q^2n^2}+j\left(m+\frac{2}{Qn}\right)}{\frac{2}{mQn}-\frac{m}{Qn}-jm}$$

(d) Low-pass shunt-derived π :—

$$\frac{\frac{1-m^2}{Q}-m^3+j\left(\frac{2m}{Q}+m^2\right)}{m^3}$$

Note that (b) and (d) give the same approximate formula.

Fig. 11 shows the relation between the insertion loss at cut-off and Q for the low-pass series-derived T whole section. The approximate formula is compared with the exact formula, and it will be seen that the discrepancy increases as m decreases, but that the agreement is generally adequate for $Q > 10$.

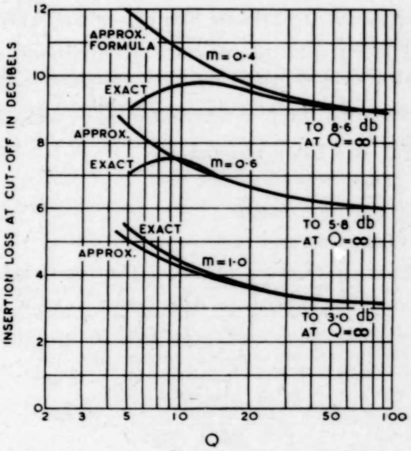


Fig. 11. *Loss at cut-off of low-pass series-derived T single section.*

Fig. 12 shows the relation between insertion loss at cut-off and Qn for the band-pass series-derived T whole section. The exact formula was used in preparing the figure. The falling-off of the loss at low Qn values for low m values is not, of course, indicated by the approximate formulas, which can therefore only be relied upon for values of Qn above, say, 5 for high m values and, say, 15 for low m values. But when n is small, so that very low values of Qn have to be considered, the values of m which can reasonably be used in practice are high, so that the approximate formulas do cover the normal range of problems.

4. The Midband Insertion Loss of a Dissipative Band-Pass Half or Whole Section

It will be shown that all whole-section arrangements give

Midband insertion loss

$$\doteqdot 20 \log_{10} \frac{2m+Qn}{Qn} \text{ db.} \quad .. \quad (11)$$

i.e. $\doteqdot 17.4\, m/Qn$ db.

and all half-section arrangements give

Midband insertion loss

$$\doteqdot 20 \log_{10} \frac{m + Qn}{Qn}\, db. \quad \ldots \quad (12)$$

i.e. $\doteqdot 8.7\ m/Qn\ db.$

These are accurate so long as $Qn \gg 1$.

Series-derived T Whole Section, as Fig. 1(*a*)

The circuits all resonate at midband, so that the network is entirely resistive. The series arms have a resistance $\frac{mR}{Qn}$, and the shunt arm has a resistance

$$\frac{QnR}{2m} + \frac{(1 - m^2)R}{2mQn}$$

$\therefore$ Insertion loss ratio

$$= \frac{\left(1 + \frac{m}{Qn}\right)\left(1 + \frac{m}{Qn} + \frac{Qn}{m} + \frac{1 - m^2}{mQn}\right)}{\frac{Qn}{m} + \frac{1 - m^2}{mQn}}$$

$$= \frac{1 + m^2 + 2mQn + Q^2n^2 + \frac{m}{Qn}}{1 - m^2 + Q^2n^2} \quad \ldots \quad \ldots \quad (13)$$

If $Qn \gg 1$, as is often the case, then we obtain equation (11) by neglecting 1, m^2 and $\frac{m}{Qn}$. The other arrangements (series derived π, shunt derived T and π) all give almost identical midband losses, and equations (11) and (13) should be taken as applying to all of them.

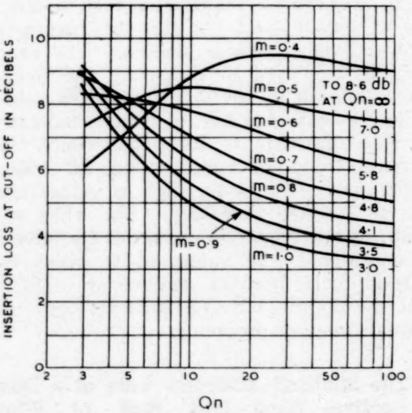


Fig. 12. *Loss at cut-off of dissipative band-pass whole section, series-derived T.*

The relationship of midband loss (as calculated from equation (13)) to Qn is shown for a number of m values in Fig. 13.

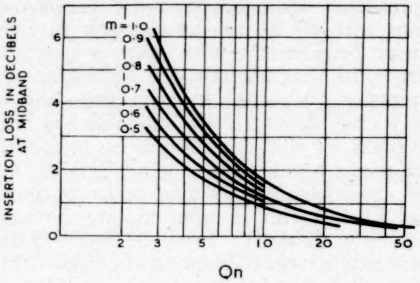


Fig. 13. *Midband loss of dissipative band-pass whole section.*

It will be observed that the midband loss is very large (of the order of 5 db. or more) at values of Qn below about 5, and such low values of Qn are not uncommon in practice.

Series-derived Half Section

Taking the type with the shunt arm in parallel with the load, we have

$$\text{insertion loss ratio} = \frac{1 + \frac{m}{Qn} + R_A}{2R_A}$$

$$\text{where } R_A = \frac{\frac{Qn}{m} + \frac{1 - m^2}{mQn}}{1 + \frac{Qn}{m} + \frac{1 - m^2}{mQn}}$$

i.e. insertion loss ratio

$$= \frac{m - m^3 + Qn\,(2 - m^2) + 2mQ^2n^2 + 2Q^3n^3}{2Qn(Q^2n^2 + 1 - m^2)} \quad \ldots \quad \ldots \quad (14)$$

and if $Qn \gg 1$, this becomes equation (12) above. Shunt-derived half sections can easily be shown to give identical midband losses.

5. Pass-Band "Distortion" of Band-pass Filters

A measure of the distortion over the pass-band is given by the difference between midband and cut-off insertion loss. This distortion is shown for the series-derived T and shunt-derived π whole sections in Fig. 14, in terms of Qn and m. The distortion is larger for smaller m values. It is to be noted that poor Q values (in relation to the bandwidth) can give reduced pass-band distortion, but since the peak attenuation is also reduced, the effect may be regarded as a "flattening-out" of the whole response.

6. An Example of Practical Responses

Fig. 15 shows a band-pass whole section response (series-derived *T*): the broken curve shows the calculated non-dissipative insertion loss, as given by equation (3), and the full line curve shows the measured insertion loss of the actual filter. The insertion losses for peak, cut-off, and mid-band frequencies as calculated from Tables I and II, and equation (11), assuming $Q = 100$, are marked also. In the practical filter, the Q values of the inductors were not all identical, but were about 100. The agreement is fairly good. It will be seen how the practical response can be estimated fairly completely from the non-dissipative frequency response and the dissipative loss at the three frequencies mentioned.

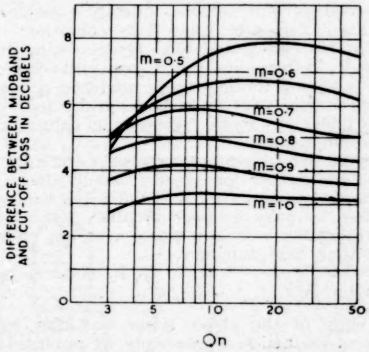


Fig. 14. *Difference between midband and cut-off loss of dissipative band-pass whole section, series-derived T or shunt-derived π.*

The image attenuation in the stop range is shown for comparison purposes. The difference between this and the insertion loss is seen to be considerable. In the pass band, owing to the large dissipation, the difference is very small. In wider band filters, and in low- and high-pass filters, the frequency range over which the image attenuation exceeds the insertion loss will be larger.

Conclusions

The extensions to Miller's paper enable the complete performance of half- and single-section non-dissipative filters of low-pass, high-pass and symmetrical band-pass types, terminated in the design resistance, to be computed as far as steady-state response is concerned.

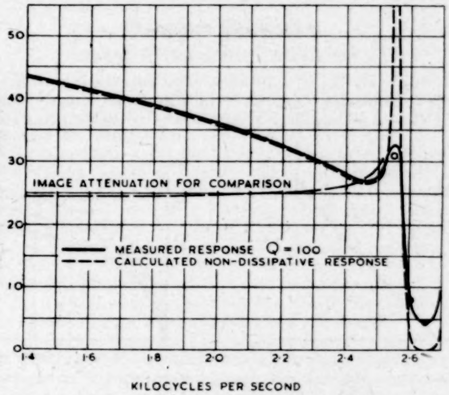


Fig. 15. *Example of practical results, band-pass whole section;* $n = 0.037$, $m = 0.884$, *midband* $= 2650$ *c/s, series-derived T.* ⊙ *Calculated loss for* $Q = 100$ *(peak, cut-off, and midband). Response is symmetrical about 2650 c/s on a logarithmic scale.*

The sections dealing with dissipative filters enable the loss at the attenuation peak, at cut-off, and (in the case of band-pass filters) at midband, to be calculated. These losses, together with the results given for the non-dissipative performance, enable the overall response of a dissipative filter to be closely estimated.

Experimental checks of a number of the formulas have been made. The author is grateful to Mr. D. C. Walker of the Post Office Research Station for criticism and assistance in checking the others.

Short Bibliography of Works giving General Filter Theory

[1] T. E. Shea, "Transmission Networks and Wave Filters," Van Nostrand, 1935.

[2] A. T. Starr, "Electric Circuits and Wave Filters," Pitman, 1934.

[3] E. A. Guillemin, "Communication Networks," Vol II, John Wiley, 1935.

[4] K. S. Johnson, "Transmission Circuits for Telephonic Communication," Van Nostrand, 1926.

[5] G. J. S. Little, "Electric Wave Filters," Inst. Post Office Elect. Engrs. Paper No. 143 (1931).

[6] R. J. Halsey, "The Design and Construction of Electric Wave Filters," Ibid, No. 147 (1932).

[7] F. Scowen, "Introduction to the Theory and Design of Electric Wave Filters," Chapman and Hall (in the press).

GOODS FOR EXPORT

The fact that goods made of raw materials in short supply owing to war conditions are advertised in this journal should not be taken as an indication that they are necessarily available for export.

CORRESPONDENCE

Letters of technical interest are always welcome. In publishing such communications the Editors do not necessarily endorse any technical or general statements which they may contain.

"Linearity Circuits"

To the Editor, "Wireless Engineer"

Sir,—In A. C. Clarke's very interesting article on "Linearity Circuits" in the June, 1944, issue of *Wireless Engineer* a slip seems to have occurred in Section 11 on Bedford's circuit. The author arrives at the conclusion that no perfect linearity can be achieved even with Bedford's circuit. Whilst I admit that owing to valve characteristic curvature no perfection can ever prevail, I should like to show briefly that under quite reasonable assumptions perfect linearity can be achieved.

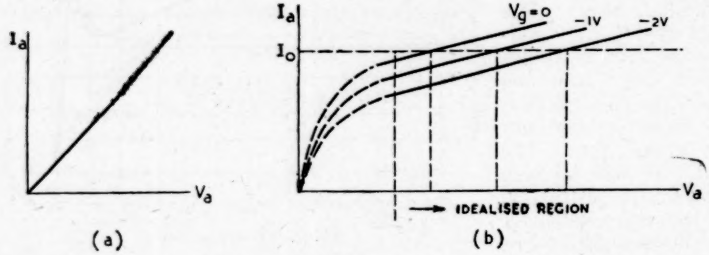


Fig. 1.

To start with, a pentode cannot be actually replaced by a simple ohmic resistance. A glance at Fig. 1(a) which gives the characteristics of a resistance, and Fig. 1(b) giving that of a pentode will demonstrate my statement. The reason is that in a pentode A.C. and D.C. resistances are two entirely different quantities, with an ohmic resistance they are identical.

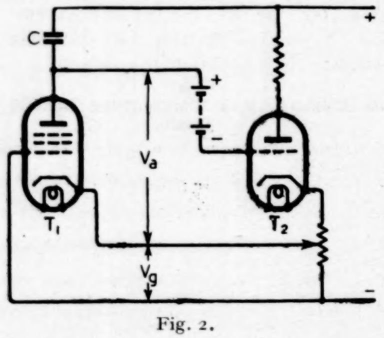


Fig. 2.

Furthermore, Bedford's circuit does not depend on an attempt to keep the anode voltage constant, as the author explains in sub-section 11.1 of his paper, but to keep the anode current I_0 constant by means of counteracting the dropping anode voltage V_a by a positively increasing grid voltage V_g (see Fig. 2).

Therefore Figs. 15(a) and (b) of Mr. Clarke's paper are not electrically equivalent, and consequently the mathematical derivation does not hold for Bedford's circuit.

If, however, one assumes that the pentode I_a/V_a characteristic in its operating range can be well approximated by a family of straight, parallel and equidistant lines as shown in Fig. 1(b) and, if one further assumes a linear triode amplifier T_2—the cathode resistance considerably helps in this assumption—it is easy enough to show that Bedford's circuit can give a perfectly linear saw tooth.

The important point is to have a constant current I_0 charging the condenser C. Then the anode voltage will decrease linearly. As can be seen from Fig. 1(b) these two conditions viz., constant current I_0 and linearly decreasing anode voltage V_a, call for a linear increase in grid voltage V_g, which in turn is automatically produced across the cathode resistance of T_2, since its grid is fed by the perfect linear saw tooth. There is no contradiction in this simple proof.

I should like to express my thanks and appreciation to the author for, what I should almost call the theorem that an exponential wave cannot be linearised by passive linear circuits. I think that such realisation will save many a useless effort to future time base designers.

G. L. Hamburger.

London, W.2.

[A copy of the above letter was sent to the author of the article whose reply we publish below —Ed.]

To the Editor, "Wireless Engineer"

Sir,—The analysis I gave was based on the condition when the grid of the pentode is returned to its cathode and hence there is no alteration of grid voltage. In this case perfect correction is not possible and my conclusion stands, though I was careful to point out that since R is not an ohmic resistance but a constant current pentode the results are better than the simple theory predicts. The circuit, however, is inferior to the true Bedford circuit in which the grid is taken to earth, and I am grateful to Mr. Hamburger for showing that under these conditions true linearity is theoretically and for all likely purposes practically possible. I append an analysis deriving the necessary circuit conditions.

I would like to bring my paper up to date by mentioning that a number of patents have recently appeared on the use of Thermistors (temperature sensitive resistances) in time-base circuits. Though I have no further details this appears to be a rather prompt verification of the prophecy in Section 12 concerning the possible future use of non-linear resistances.

I thank Mr. Hamburger for his appreciation of my "theorem" and will be very pleased if it does prove of value to time base designers.

ARTHUR C. CLARKE.

Appendix to A. C. Clarke's article, "Linearity Circuits," referred to in the above letter.

We wish to determine the condition for constant current through the pentode. If V_a, V_g, V_g' and I_a are the alternating voltages and currents in the circuit given below, and μ_p the amplification factor of the pentode, we have :—

$$\frac{V_a}{V_g} = \mu_p \quad \cdots \quad (1)$$

$$V_a = V_g' + I_aR_1 \quad \cdots \quad (2)$$

$$I_a = \frac{\mu V_g'}{R_a + Z + R_1 + R_2} = \frac{\mu V_g'}{Z_1} \quad \cdots \quad (3)$$

$$V_g = I_aR_2 \quad \cdots \quad (4)$$

From 1, 2 and 4,

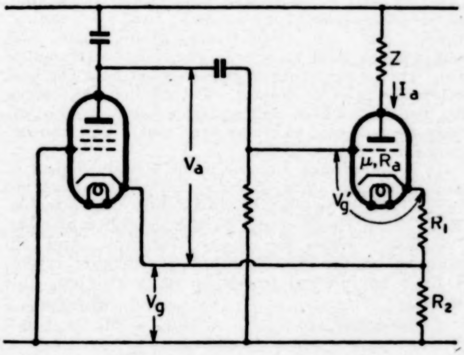
$$\frac{V_a}{V_g} = \mu_p = \frac{V_g' + I_aR_1}{I_aR_2} = \frac{V_g'}{I_aR_2} + \frac{R_1}{R_2}$$

From 3,

$$V_g' = \frac{I_aZ_1}{\mu}$$

$$\therefore \quad \mu_p = \frac{Z_1}{\mu R_2} + \frac{R_1}{R_2}$$

$$\therefore \quad \mu\mu_pR_2 = Z_1 + \mu R_1 \quad \cdots \quad (5)$$



These conditions appear to be physically realisable. Taking μ_p as 1,000 and μ as 20 gives

$$Z_1 + 20R_1 = 2 \times 10^4R_2$$

Since $Z_1 = Z + R_a + R_1 + R_2$ this may be written quite accurately

$$Z + R_a + 20\,R_1 = 2 \times 10^4R_2.$$

$Z + R_a$ would probably be of the order of 6×10^4 ohms. Then

$$60{,}000 + 20\,R_1 = 2 \times 10^4\,R_2$$

$$\therefore \quad 3{,}000 + R_1 = 1{,}000\,R_2$$

From this we conclude that if R_1, for example, is one thousand ohms, R_2 will be four ohms for the case under consideration. It is best, therefore, to split the cathode resistance of the triode between a resistor and a low value potential divider, the latter being at the earthy end of the circuit. It must be noted, however, that practical solutions of equation 5 may not be possible for all values of μ_p and Z_1.

Frequency Modulation

To the Editor, "Wireless Engineer"

SIR,—While post-war plans for television and U.H.F. sound broadcasting are under discussion, it is important that the *pros* and *cons* of F.M. should be understood. Space will not permit a full discussion here; but I wish to correct a misconception which is found even among responsible engineers, that F.M. can give no protection against ignition noise or other similar pulses which have an amplitude much greater than that of the signal carrier. The actual response of an F.M. receiver to very powerful impulsive interference can be summarised as follows.

(1) In the absence of a signal, the F.M. receiver gives no output from impulsive interference.

(2) In the presence of an unmodulated carrier to which the F.M. receiver is accurately tuned, the impulsive interference causes no audible output. If the receiver is not accurately tuned, there will be an audible output, but the amplitude of the pulses in the audio-frequency circuits of the receiver will correspond to a modulation of the carrier of less than 100 per cent., in fact to a modulation depth equal to the ratio of the frequency error in tuning to the frequency swing corresponding to full modulation of a frequency-modulated signal.

(3) In the presence of a frequency-modulated signal to which the receiver is accurately tuned, the audio-frequency noise pulses are limited to the *instantaneous* level of signal modulation. If the receiver is not accurately tuned, the amplitude of the audio-frequency pulses will be increased by the amount defined in (2) above.

If it is true, as sometimes suggested, that ignition noise is the chief trouble in U.H.F. broadcasting, this summary provides a basis for the comparison of F.M. with other systems, such as wide-band A.M. with audio-frequency limiting.

London, N.21. D. A. BELL.

Deflected Electron Beams

To the Editor, "Wireless Engineer"

SIR,—In reply to W. E. Benham's letter in the December issue, I would like to state that the expression I gave in the August issue for the induced current in a length *o* to *l* of a deflector plate system, viz.,

$$i_d = \frac{I_b}{d}y(t,t) - \frac{I_b}{d}y(t,t-\tau) + \frac{I_b}{v_bd}\int_o^l v_y\,dx$$

gives the same result for the impedance of the plates as that obtained at various times by Hollmann and Thoma, Recknagel, Rodda, and Gabor.

London, N.21. J. A. JENKINS.

To the Editor, "Wireless Engineer"

SIR,—I agree with Owen Harries that the formula proposed by Recknagel, Hollmann and Thoma and verified by Malter, Gabor and myself does not represent the true dynamic solution. The conditions postulated correspond to a quasi-stationary state, with the additional supposition that the end-fields are short compared with the forward distance moved through by an electron in a half-period. If the latter stipulation is disregarded, by having a sufficient distance of separation between the plates, a solution for the quasi-stationary state can be arrived at by using Morton's expression for the potential distribution between plates (*Phil. Mag.*, Vol. II, p. 287, 1926).

Dr. Gabor's formula for transit power gives rise to Recknagel's equation because the quasi-stationary value of ϕ has been assumed, although it was derived for ϕ dynamic.

The equation (4.1) given by Owen Harries, June issue, p. 268, should also have been Recknagel's formula if correctly derived from the premises.

In the dynamic case the appropriate equations to use are those derived by Dr. Gabor, "Energy Conversion in Electronic Devices," *Journ. I.E.E.*, Part III, Sept. 1944; for example, equations (9) or (12).

It is interesting that these relations are true whether we assume with Maxwell, that $divA =$ zero or if we put $divA = -\dot{\phi}/c$. In either case ϕ will not be the quasi-stationary value of ϕ, but should be recalculated with the new values of charge distribution. In addition since the term $\dot{A}/c$ in the expression for E already involves terms in $1/c^2$, it is necessary to employ the correction for mass variation with electronic velocity in working to this degree of precision. It is doubtful if the introduction of these corrections affects the result to nearly the same degree as the end-effect correction already referred to, unless the deflector plates exceed, say, $\lambda/8$ in length.

The claim that equation (31) of Owen Harries' paper represents the ratio between "the power used to deflect the beam and the power carried by the beam" is inadmissible, as may be seen by allowing the frequency to tend to zero. The deflection angle remains finite, but the deflecting power certainly becomes zero.

Incidentally I have examined the correction to be applied to Perry and Chaffee's determination of the ratio $\mathcal{E}/m_0$ (*Phys. Rev.*, Sept. 1930, p. 904), supposing that Recknagel's method can be applied to give the variation in forward velocity. The correction is found to be negligibly small (approx. 1 in 10,000), but increases as $(l/L)^2$, where l is the length of the deflector plates, and L the separation down the tube between the centres of the two pairs of deflecting plates. The sign of the correction is such as to reduce the experimentally determined value.

New Barnet, Herts. S. Rodda

Mass, Volume and Surface Resistivity

To the Editor, "Wireless Engineer"

Sir,—My attention has been drawn to the Editorials on this subject in your May, July and August, 1944, issues. Prof. Howe has probably long since discovered the convenience of so-called mass resistivity in calculating wire resistances; but even so the following explanation may be of value to others. Convenient data, measurable with great accuracy, are mass per unit length, $W_1 = W/l$, and resistance per unit length, $R_1 = R/l$. Denoting density by δ, "volume" resistivity by ρ, and cross-sectional area by A, we have

$$W = lA\delta, \quad R = \rho l/A.$$

Hence $W_1 = A\delta, \quad R_1 = \rho/A$;

so that $R_1 = \delta\rho/W_1$.

Thus a knowledge only of the mass resistivity $\delta\rho$ permits the immediate deduction of resistance per unit length from mass per unit length, and *vice versa*. The advantage is that the wire diameter, usually measured with relative inaccuracy, is not required in the calculation, since A, the inaccuracy of which is still greater, has been eliminated. Also the formula is not limited to circular cross-sections, and departures from circularity do not affect its accuracy.

The relation given is valuable in the submarine cable field, in which a peculiar unit of length is used, the nautical mile (n.m.) of 2,029 yards. Several companies still adhere to the old B.A. ohm. = 0.9866 Int. ohm. In 1928 I calculated the mass resistivity of standard annealed copper, as defined by the I.E.C. and B.S.I., namely 15.3276 (Int.) $\mu\Omega$-gm/cm^2 at 20° C., to be 1163.17 Int.Ω-lb./n.m.^{2}. Correcting to 75°F., the usual test temperature for submarine core, gives 1180.8 Int.Ω-lb/n.m.^{2}, or 1196.8 B.A.Ω-lb./n.m.^{2}, and these values have since appeared in various specifications. The temperature correction involves the coefficient of expansion as well as the "constant mass" resistance coefficient.

As regards terminology, no doubt "density-resistivity," although rather a tongue-twister, is more suitable than "mass resistivity"; but I think "volume" resistivity is only needed in contexts where there is a liability of confusion with "surface" resistivity. Perhaps "internal" and "superficial" resistivity would be preferable, although also more long-winded. Strictly speaking, their units are respectively ohm-cm^2/cm and ohm-cm/cm, and it is advantageous to remember this when converting to shapes other than the unit reference cube or square. In practice we seldom do deal with cubes and squares, but it would perhaps be pedantic to retain the 'cms" that can be cancelled in these units.

It is sometimes difficult to be strictly logical in nomenclature, since so many different names are required, but the effort is worth while when possible. Even Prof. Howe (July, p. 307) is guilty of using "weight" when he means "mass." And, on account of the possibility of overlooking errors, I have an infernal resistance to despatching this letter!

A. L. Meyers.

London, S.E.10. (T. C. & M. Co. Ltd.).

Book Review

Ultra-High-Frequency Radio Engineering

By W. L. Emery. Pp. 295 + x, with 136 Figs. The MacMillan Company, 60, Fifth Avenue, New York, 1944. Price $3.25.

During the past few years many teachers of technical subjects in colleges and Universities have experienced the need for adequate modern text-books covering the basic principles of radio applications. In the preface of the book under review the author states that in order to organise a course of instruction in "Ultra-high-frequency Techniques" at Iowa State College, he found it necessary to prepare a set of lecture notes for the use of his students. After eighteen months, teaching experience, these notes have been revised and developed into the present text.

The scope of the book, although not defined as precisely as it should be by a teacher, appears to be the field of radio technique at frequencies above about 30 megacycles per second, thus embracing the bands of very-high, ultra-high and super-high frequencies in the only classification which has so far received international agreement*. From the first line of the first chapter, the author uses the term " microwave " as if it corresponded exactly with that of " ultra-high-frequency " given in the title. The reviewer has never been very clear as to the precise meaning of the term " microwave," but he is willing to accept the definition given in the preface of Professor J. C. Slater's book on " Microwave Transmission," viz., electromagnetic waves of wavelengths between 1 centimetre and 1 metre. Professor Slater's book is referred to on pp. 160 and 261 of the one under review, so the author should be clear as to the meaning of the terms he uses.

The general layout of Mr. Emery's book comprises an introduction and ten other chapters, each describing a specific section of the subject, with the aid of clear diagrams, some mathematics and numerical calculations, and terminating with a few exercise problems, descriptions of some practical experiments and a list of references to more advanced literature on the subject of the chapter. The material provided is devoted to the principles of equipment design and their application to the engineering side of the subject, and much space is devoted to the important auxiliary items which are necessarily associated with modern radio equipment. Chapters II to VI, for example, deal successively with " Voltage-regulated Power Supplies," " Electronic Switching and Synchronisation," " Cathode-ray Tubes and Sweep Circuits," " Amplifiers," and " Square-wave Testing and Transient Response " ; the technique of these subjects is by no means confined to frequencies above 30 megacycles per second. The next three chapters deal in a similar manner with ultra-high-frequency circuits and oscillators and the subject of modulation and detection. The book ends with two chapters dealing with antenna arrays and wave propagation and with waveguides respectively ; except for some points mentioned below, these appear to be satisfactory, though necessarily very brief, reviews of these sections of the subject. Some space and not a little confusion might have been saved, however, by omitting the section on propagation ; since this deals chiefly with the travel of radio waves through the ionosphere and not with the transmission of very short waves through the lower atmosphere. In fact, the statement on p. 259, " The transmission of microwaves is not hindered by the presence of fog or mist or rain or snow," taken with a somewhat similar statement on p. 3, suggests that the author is under a misapprehension as to the relative effects of weather conditions on the transmission of long and very short radio waves.

The reviewer believes that he is not attempting to mislead the reader by reproducing the following extract from p. 240 without an unduly large amount of context. " . . . an antenna mounted parallel to the (electric field) . . . will cut a maximum possible number of magnetic lines of force and will have a maximum voltage generated in it. At the same time, it will also pick up a voltage from the electric-field intensity lines." This recalls the old fallacy inherent in devices which purported to extract the electric and magnetic energy of a wave train in separate receivers. In contrast with these comments, the use of red and black ink in the diagrammatic representation of the electric and magnetic fields in space and in waveguides, in Figs. 115, 116 and 126, is to be commended to the attention of other authors and publishers.

In conclusion, it may be said that while those responsible for teaching the subject of radio engineering would do well to look at this book for some ideas and general guidance, it is doubtful if they will feel that it completely meets the need for a satisfactory text-book covering the subject under consideration. R. L. S.-R.

Institution of Electrical Engineers

At a meeting of the I.E.E. Radio Section, on February 7th, Flt.-Lt. C. B. Bovill will give a paper on " Aerials for use on Aircraft—a comparison between fixed and trailing types on the 900-metre waveband."

A discussion on " Aspects of Post-War Valve Standardisation " will be opened by A. H. Cooper at the meeting on February 20th.

" Multipath Interference in Television Transmission " will be dealt with by D. I. Lawson in his paper on February 28th.

Dr. K. R. Sturley will deliver a paper on " Frequency Modulation " at the meeting on March 7th.

All these meetings of the Radio Section begin at 5.30 at the I.E.E., Savoy Place, London, W.C.2.

Two meetings of the I.E.E. Cambridge Radio Group will be held at the Cambridgeshire Technical College during the month. That on February 13th will be devoted to a paper by Prof. Willis Jackson and J. S. A. Forsyth on " The Development of Polythene as a High-Frequency Dielectric." On February 26th, Dr. Alex. Wood will lecture on " The Acoustic Design of Broadcasting Studios." Both meetings will commence at 6 o'clock.

At a meeting of the London Students' Section of the I.E.E. to be held on February 13th, Dr. W. Wilson will lecture on " The Cathode-Ray Tube and its Applications." The meeting will begin at 6.30.

Other Meetings

A DEMONSTRATED lecture on sound reproduction will be given by P. G. A. H. Voigt at the first meeting of the Spring Term of the City and Guilds Radio Society at the City and Guilds College, Exhibition Road, London, S.W.7, at 5.15, on February 9th.

Dr. H. P. Williams will give a paper on " Vertical *v* Horizontal Polarisation " at a meeting of the Television Society on February 27th, at 6 o'clock, at the I.E.E., Savoy Place, London, W.C.2.

H. L. Kirke, Head of the B.B.C.'s Research Department, will lecture on " Some Aspects of Pre-war and Post-war Television " at the " Friday Evening Discourse " at the Royal Institution, 21, Albemarle Street, London, W.1, on March 2nd, at 5 o'clock.

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* See *Wireless Engineer*, 1942, Vol. 19, p. 360.

WIRELESS PATENTS

A Summary of Recently Accepted Specifications

The following abstracts are prepared, with the permission of the Controller of H.M. Stationery Office, from Specifications obtainable at the Patent Office, 25, Southampton Buildings, London, W.C.2, price 1/- each.

ACOUSTICS AND AUDIO-FREQUENCY CIRCUITS AND APPARATUS

564 427.—Sound-recording system with control of volume compression and expansion, and of carrier-current amplitude, say, for radio broadcasting.

Radio Corporation of America. Convention date (U.S.A.), 24th March, 1942.

564 654.—Rotary switch for producing signalling pulses of predetermined timing.

Londex Ltd. and W. S. F. Brown. Application date, 12th April, 1943.

DIRECTIONAL WIRELESS

564 445.—Means for varying, without undesirable interaction, the relative phase of the currents fed to the two aerials of an equi-signal radio beacon.

Marconi's W. T. Co. Ltd. and E. Green. Application date, 25th March, 1943.

564 572.—Directional receiving installation, with provision for automatically resolving the "sense" ambiguity, and for rotating the directional aerial into a corresponding position.

Sperry Gyroscope Co. Inc. (assignees of J. E. Browder and F. L. Moseley). Convention date (U.S.A.), 3rd July, 1941.

RECEIVING CIRCUITS AND APPARATUS

(*See also under Television*)

564 014.—Receiver for phase-modulated signals in which the carrier frequency is "exalted" either by a locally-injected wave, or otherwise.

Marconi's W.T. Co. Ltd. (assignees of R. E. Schock). Convention date (U.S.A.), 23rd May, 1942.

564 047.—Varying the position of the powdered-iron core of a tuning inductance by means which involve the formation of a screw thread on the inner surface of the coil former, but not on the core.

E. K. Cole Ltd. and A. E. King. Application date, 31st May, 1943.

564 114.—Click-action mechanism for use with rapid tuning control operated by a rotary shaft.

Philips Lamps Ltd. and C. L. Richards. Application date, 9th March, 1943.

564 160.—Valve socket for ultra-high-frequency working, including a series-tuned circuit for maintaining one or more of the electrodes at earth potential.

Marconi's W.T. Co. Ltd. (assignees of R. M. Smith). Convention date (U.S.A.), 31st January, 1941.

564 236.—Frequency-discriminating circuit comprising a valve which is shunted by a series-tuned circuit in parallel with a pair of balanced diodes.

The General Electric Co. Ltd. and J. B. L. Foot. Application date, 16th June, 1943.

564 243.—Short-wave amplifier in which a tapping from the output circuit is arranged to offset damping in the input circuit.

The British Thomson-Houston Co. Ltd. Convention date (U.S.A.), 22nd June, 1942.

564 319.—Valve amplifier in which an automatic bias is provided to offset the effect of variations on the supply voltage.

Standard Telephones and Cables Ltd. and M. M. Levy. Application date, 19th March, 1943.

564 410.—Selective relay system, applicable, say, to the remote control by radio of an aeroplane or other navigable craft.

W. W. Triggs (communicated by Philips Lampen, A. G.). Application date, 12th June, 1942.

564 444.—A.V.C. system in which the final output from the set varies the degree of negative feed-back applied to a preceding L.F. amplifier, so as to ensure compensation over a range both of radio and audible frequencies.

Marconi's W. T. Co. Ltd. and G. I. Hitchcox. Application date, 25th March, 1943.

TELEVISION CIRCUITS AND APPARATUS

For Transmission and Reception

564 250.—A push-pull amplifier for feeding television or like signals directly to a low-impedance load, such as a transmission line, without the use of a coupling transformer.

E. L. C. White. Application date, 7th September, 1940.

564 425.—Cathode-ray tube in which the fluorescent screen is arranged to show the televised picture with clear-cut edges, without using a mask.

Philco Radio and Television Corporation (assignees of J. S. Vansant). Convention date (U.S.A.), 30th March, 1942.

TRANSMITTING CIRCUITS AND APPARATUS

(*See also under Television*)

564 041.—Frequency-modulating system in which an auxiliary pilot current is utilised to apply volume compression at the transmitter and volume expansion at the receiver.

Marconi's W.T. Co. Ltd. (assignees of W. R. Koch). Convention date (U.S.A.), 27th May, 1942.

564 045.—Phase-modulation system in which the carrier is split into three phase-differentiated components to ensure linearity between the final signal and the modulating voltage.

The British Thomson-Houston Co. Ltd. Convention date (U.S.A.), 28th May, 1942.

564 135.—Two-way signalling circuit in which an oscillator valve used for transmission serves as a super-regenerative detector in reception.

Hazeltine Corpn. (assigneees of N. P. Case). Convention date (U.S.A.), 8th May, 1942.

564 247.—Monitoring installation designed to give a continuous visual indication of the modulation level of a frequency-modulated signal.

Marconi's W. T. Co. Ltd. (assignees of J. McC. Brumbaugh). Convention date (U.S.A.), 19th June, 1942.

564 323.—Means for varying the tuning, through a transmission line, of a distant short-wave transmitting aerial of fixed physical dimensions.

Standard Telephones and Cables Ltd. ; E. G. Seath ; and K. Highnam. Application date, 19th March, 1943.

564 331.—Ensuring a constant signal-deviation response in a frequency-modulating system in which the main oscillator is also subject to another variable control.

The General Electric Co. Ltd. and L. C. Stenning. Application date, 16th June, 1943.

564 357.—Short-path cooling system for the anode of a high-powered electron-discharge device.

Marconi's W. T. Co. Ltd. (assignees of F. C. Blancha). Convention date (U.S.A.), 31st December, 1941.

564 504.—Variable-reactance valve circuit designed to give a wide range of linear response in a frequency-modulating system.

The British Thomson-Houston Co. Ltd. Convention date (U.S.A.), 11th July, 1942.

564 511.—Transmitting television and sound on the same carrier wave, the sound signals being superposed in the form of phase-modulated pulses of constant amplitude.

S. R. R. Kharbanda and Pye Ltd. Application date, 7th January, 1943.

CONSTRUCTION OF ELECTRONIC-DISCHARGE DEVICES

564 003.—Cathode-ray tube with a cylindrical electron lens assembly of small transverse dimensions and long focal length.

Standard Telephones and Cables Ltd. (assignees of K. Spangenberg). Convention date (U.S.A.), 7th May, 1942.

564 022.—Construction and assembly of the metal envelope and cooling fins of a high-powered electron-discharge device.

The M-O Valve Co. Ltd. and T. F. B. Hall. Application date, 16th January, 1942.

564 193.—Stabilised electron-beam amplifier applied for keeping a Wheatstone bridge automatically balanced, or for indicating the movement of an object.

H. Ziebolz. Convention date (U.S.A.), 22nd December, 1941.

564 194.—Electron-beam amplifier in which secondary emission effects produced on a target placed between two anodes are utilised to stabilise the operation of the tube.

H. Ziebolz. Convention date (U.S.A.), 6th December, 1941.

564 382.—Arrangement of the intercepting anodes in a beam-deflection relay of the cathode-ray type.

H. Ziebolz. Convention date (U.S.A.), 22nd April, 1942.

564 441.—Method of assembling short-wave valve electrodes which are separated only by a coating of insulating material.

The Mullard Radio Valve Co. Ltd. ; R. G. Clark ; and L. M. Myers. Application date, 19th August, 1942.

564 494.—Electrode arrangement and assembly, and the casing, say, of a pentode valve intended to be sealed into a submarine cable.

Western Electric Co. Inc. Convention date (U.S.A.), 21st April, 1942.

564 546.—Assembly and alignment of the electrodes of a cathode-ray tube designed to give a fine trace and to respond to high modulating frequencies.

G. Liebmann and Cathodeon Ltd. Application date, 2nd November, 1942.

564 601.—Assembly and alignment of the electrode system of an amplifier of the beam type.

G. Liebmann and Cathodeon Ltd. Application date, 29th October, 1942.

SUBSIDIARY APPARATUS AND MATERIALS

564 222.—Method of mechanically and electrically bonding the terminals of a photo-electric cell of the dry-disc type.

Sangamo Weston Ltd. Convention date (U.S.A.), 22nd July, 1942.

564 244.—Dry-plate rectifier with a blocking layer which is superposed on successive coatings of halogenated and vitreous selenium.

The British Thomson-Houston Co. Ltd. Convention date (U.S.A.), 22nd June, 1942.

564 396.—Excitation circuit, resonant to the supply frequency, for a gas-filled rectifying valve.

The British Thomson-Houston Co. Ltd. Application date, 24th March, 1943.

564 455.—Arrangement of the terminal strips or terminals of electrolytic and like fixed condensers.

British Insulated Cables Ltd. and W. C. Handley. Application date, 5th June, 1943.

564 505.—Radio altimeter in which sinusoidally-modulated waves are radiated from an aeroplane, and, after reflection from the earth's surface, are compared in phase with the original modulating frequency to indicate the height.

J. Forman and Pye Ltd. Application date, 6th March, 1941.

564 621.—The use of reinforcing strips or laminae for increasing the mechanical rigidity of the powdered-iron cores of H.F. coils.

Automatic Telephone and Electric Co. Ltd. ; J. Bylewski ; and A. Davidson. Application date, 1st April, 1943.

564 651.—Process for making the fine metallic dust used in the cores of H.F. inductance coils.

Standard Telephones and Cables Ltd. and W. E. Laycock. Application date, 2nd April, 1943.

564 661.—Arrangement and construction of the fixed condensers used in filter circuits for eliminating static interference.

Dubilier Condenser Co. (1925) *Ltd. (communicated by W. Dubilier). Application date, 8th May,* 1943.

ABSTRACTS AND REFERENCES

Compiled by the Radio Research Board and published by arrangement with the Department of Scientific and Industrial Research

Comparative Length of the Abstracts.—*It is explained to new readers that the length of an abstract is no sign, by itself, of the importance of the work concerned. An important paper in English may be dealt with by a short abstract, or even, if it is in a journal readily obtainable, by a square-bracketed addition to the title ; while a paper of similar importance in a language other than English may be given a long abstract. In addition to these questions of language and accessibility, the nature of the work has, of course, a great effect on the useful length of its abstract.*

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PROPAGATION OF WAVES

384. IMPEDANCE CONCEPT IN WAVE GUIDES.—S. A. Schelkunoff. (*Quart. Applied Math.* [Brown University], April 1944, Vol. 2, No. 1, pp. 1–15.)

" In the course of various private discussions, I have found that there exists some uneasiness with regard to the applicability of the concept at very high frequencies . . . Some particular aspects of the concept have to be sacrificed in the process of generalisation, and although these aspects may be logically unimportant, they frequently become psychological obstacles to understanding in the early stages of development. For this reason I am going to devote several sections of this paper to a general discussion of the impedance concept before passing to more specific applications ; then by way of illustration I shall prove that an infinitely thin perfectly conducting iris between two *different* wave guides behaves as if, between the admittances of its faces, there existed an ideal transformer. This theorem is a generalisation of another theorem which I proved several years ago to the effect that when two wave guides are alike, the iris behaves as a shunt reactor. Actual calculation of the admittances and the transformer ratio depends on the solution of an appropriate boundary-value problem.

" More generally, wave-guide discontinuities are representable by *T*-networks. In some special cases these networks lack series branches, and in other cases the shunt branch."

385. RADIO DATA CHARTS : NO. 17—ATTENUATION OF WAVE GUIDES.—J. McG. Sowerby. (*Wireless World*, Nov. 1944, Vol. 50, No. 11, pp. 328–331.)

386. THE INVESTIGATION OF THE PROPAGATION OF ELECTROMAGNETIC WAVES IN MOUNTAIN AND RIVER VALLEYS, FIORDS, ETC., BY MEANS OF MODELS.—B. Polić. (*T.F.T.*, April 1944, Vol. 33, No. 4, pp. 63–78.)

The peculiarities of reception, or rather non-reception, in such terrain are well known in practice and have been explained in various ways, but never really satisfactorily or consistently. For instance, Fritsch found that in narrow valleys it was impossible to receive on long waves but comparatively easy on short and ultra-short (2052 of 1937 and back references). Various explanations were adopted, the most popular being the assumption of a frequency-dependent absorption of the waves, of such a kind that the absorption *decreases* with increasing frequency : this contradicts all theoretical considerations and also practical experience.

" Only in one place in the literature [Vilbig's book, 2274 of 1943, is here referred to] is the suggestion made that what is involved is the so-called ' tube-wave ' effect—that in wave propagation in valleys and fiords, as in propagation in wave guides of round or rectangular cross-section, there must exist a quite definite limiting frequency and limiting wavelength corresponding to the geometrical dimensions of the valley. In the case in point, this means that the waves longer than the critical wavelength of the valley can either not be received at all or can be received only in a greatly attenuated condition, whereas waves below the critical wavelength can be received without difficulty.

" Experiments to establish radio communication with points beneath the earth's surface, such as in caves, mines, and the like, showed the same phenomena . . . Here also it seems likely that the ' tube-wave ' effect is involved. Moreover, it has often been found that in direction-finding work in or above a valley, bearing errors in the direction of the valley occur.

"The practical importance of the present work is the establishment of the bases of wave propagation in systems, such as river and mountain valleys, fiords, caves, mines, etc., whose geometrical dimensions are of the same order of magnitude as the wavelength concerned. By such knowledge the further experimental investigation and the planning of radio communications are made easier." A mathematical treatment of the problem encounters great difficulties and in many cases represents an insoluble task; an experimental investigation was therefore undertaken, using "valley models" constructed of wood and galvanised iron sheet 8 m long, nearly 2 m high, and with a bottom nearly 1 m wide.

The writer summarises his results as follows:— "In the propagation of electromagnetic waves in a valley, the limiting-wave effect is found exactly as in the propagation of electromagnetic waves in wave-guides of rectangular cross-section. The limiting-wave effect shows itself only with vertically polarised waves and waves whose polarisation is horizontal and parallel to the walls of the valley: waves with polarisation horizontal but at right angles to the valley-walls show no limiting-wave effect. The limiting wavelength is equal to twice the width of the valley.

"If the waves are propagated transversely over the valley, only those waves penetrate into the valley which are shorter than the limiting wave: an exception is the wave with polarisation horizontal and at right angles to the valley-walls. In the valley itself [both for vertically polarised waves and 'horizontal-parallel' polarisation] there always occurs a horizontal component of the electric field [perpendicular to the walls], whatever the length and polarisation of the waves may be."

The tests were carried out first with a model with parallel sides, and repeated (pp. 74–77) with a model having sloping sides, and thus more closely resembling an actual valley. The only differences are those due to the fact that the valley-width (and with it the limiting wavelength) now varies with height above the bottom of the valley. As before, with waves propagating transversely above the valley a horizontal component of the electric field is formed in the valley. "The valley exerts no special damping or damping-reducing action on the waves" [this result, and its disagreement with many practical observations, is discussed in the last paragraph of section VI, on p. 78: the discrepancy is attributed to the high conductivity of the model-surfaces leading to reflection and not absorption].

Practical conclusions include the following:— (i) For communication in a valley the wave used must be shorter than the limiting wave of the narrowest part of the valley: "for this purpose, vertically polarised waves are the best." If waves longer than the limiting wave are to be used, these must have their polarisation horizontal and at right angles to the valley-walls; attenuation will, however, be greater than with the vertically polarised waves shorter than the limiting wavelength. (ii) For a receiver situated in a valley, a vertical aerial is best for ground waves and vertically polarised waves; but in many cases it is possible to use a horizontal aerial perpendicular to the valley-walls, because of the formation, already mentioned, of the horizontal component by waves of any length and polarisation passing transversely above the valley. This component is, however, comparatively weak. (iii) It is just the occurrence of this horizontal component, at right angles to the sides of the valley, that causes great difficulties in direction-finding work in or over a valley. "This fact has been observed in many tests and measurements, but unfortunately has been little investigated. Practically nothing can be found about it in the literature."

387. ELECTRICAL FIELD NEAR A DEPRESSION IN A CONDUCTING PLANE.—V. A. Fock. (*Comptes Rendus (Doklady) de l'Acad. des Sci. de l'URSS*, 30th Sept. 1943, Vol. 40, No. 9, pp. 343–345: in English.)

"Imagine an absolutely conducting plane with a depression (for instance, in the form of a hemisphere) whose surface is likewise an absolute conductor of electricity. Suppose a radio wave of length λ, very large compared to the linear dimensions a of the depression, to fall upon the plane. Then one may introduce a length l such that $a \ll l \ll \lambda$. In a volume with linear dimensions l adjoining the depression, the field may be looked upon as electrostatic (because $l \ll \lambda$). On the other hand, as $a \ll l$, the boundary conditions for this electrostatic field may be taken such as if it were occupying all the space over the plane.

"In that way, the problem of determining the field due to a radio wave is reduced to the following electrostatic problem:—The value E of the constant electrostatic field at a great distance from the plane being given, we are to determine the potential Φ which satisfies Laplace's equation, behaves at infinity like Ez, and vanishes on the conductor. (The field at infinity is perpendicular to the conducting plane which we take for the z-plane.)

"The problem will be solved here for the case when the depression is formed by a spherical surface crossing the plane at an angle γ . . ." The depression may be negative, so that the surface is convex. Toroidal coordinates are employed, and use is made of the writer's theorem (598, below) on the expansion of an arbitrary function in an integral involving Legendre functions with a complex index.

388. FRESNEL'S REFLECTION FORMULAE AND PARALLEL TRANSMISSION LINES [Extension of Howe's "Transmission-Line Treatment" of a Plane Electromagnetic Wave to the Case of a Wave incident Obliquely on a Second Medium].—A. Bloch. (*Wireless Engineer*, Dec. 1944, Vol. 21, No. 255, pp. 560–562.)

389. SOLUTIONS OF PROBLEMS RELATING TO MEDIA IN CONTACT, BY THE METHOD OF WAVE-TRAINS.—Green. (*See* 605.)

390. LONG-DISTANCE "BURSTS" ON THE VERY-HIGH-FREQUENCY BAND.—F.C.C. (*QST*, Aug. 1944, Vol. 28, No. 8, p. 58: paragraph only.) *See* 3455 of 1944. The greatest number occur at sunrise, the fewest at sunset.

391. RADIO INVESTIGATION OF AIR MOVEMENT IN THE UPPER ATMOSPHERE.—O. P. Ferrell. (*Sci. & Culture* [Calcutta], June 1944, Vol. 9, No. 12, p. 555.)

For previous work *see* 1105 of 1944. "Investigation of eddies and circulation in the earth's upper atmosphere may be greatly aided by reduction of observations of long-range very-high-frequency radio signals. It is fairly well known that propagation of wave trains of the order of 60 000 kc/s is possible from small plane areas, or patches, or clouds of extremely high ionic density within the E region. This is commonly referred to as 'abnormal' or 'sporadic E' (E_s).

"A consideration of a particular manifestation of E_s has been examined by the writer. Very extensive observations in North America on 5th June, 1938, and 22nd July, 1938, have been reduced. On both occasions the apparent skip distance was observed to drift at a specific rate of speed. The skip distance, or the far boundary of the zone of silence, on the first occasion progressed 850 km in 1 hr 50 min. On the latter occasion it was observed to progress over 900 km in 1 hr 40 min.

"With correlating data from the Cheltenham Magnetic Observatory on the virtual height (115 km) and ionic density (exceeding 3.5×10^6 free electrons per c.c.) an estimate of the lateral drift of the sharply-defined discontinuity was prepared. The average velocity of drift was found to be 120 km/hr. In the first case the eddy was indicative of an easterly air current. In the latter the flow was apparently from the south-east.

"Through the cooperation of Dr C. P. Oliver, Director of the Cook and the Flower Observatories, 25 selected long-enduring meteor trains were applied as a partial confirmation of this hypothesis (ref. '1'). It was immediately noticed that the predominant drift over the North American continent was to the north, tending west. The average of the two values, measured and assumed, for night trains at 88 km was 194 km/hr. Although there were indications of increasing circulation with increasing heights, no specific inferences could be drawn. Undoubtedly, however, considerable instability exists in this region.

"The findings of Dr Oliver were in opposition to those of Kahlke (ref. '2'). Turbulence and eddies of 100 km/hr at heights from 60 to 110 km are among his 26 observations. Kahlke & Barnard (ref. '3'), utilising 80 examples, found a prevailing easterly movement at night, indicating a west wind.

"Theoretically, if the atmosphere at 40 km becomes a few degrees warmer during the daylight hours, air circulation will be from the night areas to the daylight areas at certain heights. At nominal altitudes above this, the prevailing wind shall be continually 180° out of the phase. The establishment of these heights can be greatly aided by reduction of variations in the skip distance during periods of E_s."

392. METEOR OBSERVATIONS DURING 1941/42 [including a Discussion of Persistence, Colour, & Size of Streaks (and the Influence of the Electrical Condition of the Upper Atmosphere: "Ionisation plays a Very Important Part in the Development of Meteor Trains"): etc.].—M. A. R. Khan. (*Nature*, 21st Oct. 1944, Vol. 154, No. 3912, p. 520: summary, from *Journ. Hyderabad Acad.*)

393. REPORTS ON RECENT METEOR [Mid-Western U.S. Skies, 18th August, 1944] NEEDED BY SCIENTISTS.—C. P. Olivier. (*Sci. News Letter*, 2nd Sept. 1944, Vol. 46, No. 10, p. 152.) For results of the appeal *see* issue for 30th September, No. 14, p. 217.

394. THE EFFECT OF THE TROPOSPHERE ON THE PROPAGATION OF ULTRA-SHORT WAVES: A SUMMARY.—B. A. Vvedenski. (*Izvestiya Akad. Nauk S.S.S.R.* [*Bull. de l'Acad. des Sci. de l'URSS, Série Physique:* in Russian], No. 4, Vol. 7, 1943, pp. 93–95.)

The following effects on the propagation of ultra-short waves, due to the non-uniform nature of the troposphere, can be established with an accuracy sufficient for practical purposes.

(1) Refraction takes place owing to the continuous decrease of the coefficient of refraction n with altitude h in accordance with the formula $n^2 = \epsilon = \epsilon_0 - gh$, where ϵ is the dielectric constant of air at altitude h and ϵ_0 and g are constants. (2) Sharply defined rather variable non-uniform layers exist in the troposphere, and at each boundary ϵ experiences an abrupt change which is sufficient to cause reflection. The above two phenomena are in no way connected with the ionisation which takes place at higher layers.

(3) In regions close to the transmitter (up to $\frac{1}{2}$ to $\frac{3}{4}$ of the distance to the horizon) reflection is hardly observable and the "average" refraction can be calculated from formulae derived by Schelling, Burrows, & Ferrell, 1933 Abstracts, p. 318. (4) Beyond these distances it is necessary to take diffraction into account. Formulae derived for this purpose by Englund, Crawford, & Mumford (417 of 1939) are not reliable since they are based on optical laws not applicable to the problem under consideration. Further confirmation of these formulae by Eckersley & Millington (3835 of 1938) is also of doubtful value since the method of phase integrals used by these authors is based exclusively on analogies and not always strictly justifiable mathematical approximations. The author refers to his own formulae derived in the present journal, Vol. 6, 1942, p. 41 onwards (and *cf.* 623 of 1942). The main difference between the two sets of formulae lies in the method for calculating the diffraction coefficient β. This leads to opposite conclusions as to the effect of diffraction on the field intensity E; according to Englund and Eckersley E, *ceteris paribus*, always increases when refraction takes place, while according to the author the contrary, *ceteris paribus*, nearly always holds good.

(5) The author's conclusion is usually contradicted by citing the fact that the curve calculated in accordance with Englund and Eckersley passes between the maximum and minimum observed values of E. It is pointed out, however, that the experimental curves are affected not only by refraction but by reflecting layers as well. Thus in studying the only known experiments during which the reflecting layers were definitely absent (417 of 1939) much closer approximation to the observed values is obtained if the author's formulae are used in place of those of Englund and Eckersley.

395. ON THE EFFECT OF POLAR AND PARAMAGNETIC MOLECULES ON THE ABSORPTION AND REFRACTION OF RADIO WAVES IN THE ATMOSPHERE.—V. L. Ginsburg. (*Izvestiya Akad. Nauk S.S.S.R.* [*Bull. de l'Acad. des Sci. de l'URSS, Série Physique:* in Russian], No. 4, Vol. 7, 1943, pp. 96–98.)

It is pointed out that there are in the atmosphere a large number of molecules possessing magnetic and electric moments, such as, for example, the O_2 molecules of which under normal atmospheric pressure there are 5×10^{18} per cm^3. There are also a considerable number of water molecules with an electric dipole moment.

The effect of paramagnetic molecules on the propagation of radio waves was investigated in detail by the author elsewhere (*Comptes Rendus* (*Doklady*) *de l'Acad. des Sci. de l'URSS*, Vol. 35, 1942, p. 302 onwards). In the present paper a short survey of this investigation is given and it is stated that this effect is extremely small, lying just on the border of possible experimental observations (in the case of the O_2 molecules). It is pointed out that the insignificance of the effect is mainly due to the prominence in this case of negative absorption and dispersion.

With regard to polar molecules, *i.e.*, water molecules, in the earth's atmosphere, the following effects are possible :—(1) Absorption and radiation of electromagnetic waves by the molecule during its transition from one rotation level to another : the corresponding frequencies lie, however, within the region of millimetric and shorter waves. (2) Orientation and subsequent splitting of the molecule due to the constant electric field of the earth. This process can be accompanied by absorption and radiation of electromagnetic waves.

An investigation of the second effect was made by Holmes (2176 of 1938) who, however, estimated the frequency of oscillations and the absorption coefficient by starting from classical premisses which are totally inadequate for this particular case. The results obtained by Holmes are therefore incorrect in all respects. Thus it is shown that the natural frequency of oscillations is somewhere at or below 1 c/s, and not of the order of 10^9 c/s as estimated by Holmes. It can therefore be concluded, contrary to Holmes's ideas, that the effect of polar molecules on the propagation of radio waves in the atmosphere is completely non-existent.

396. ON THE PROPAGATION OF RADIO WAVES OVER THE SURFACE OF THE EARTH, TAKING INTO ACCOUNT THE NON-UNIFORMITY OF THE ATMOSPHERE AND THE SPHERICAL SHAPE OF THE EARTH.—G. A. Grünberg. (*Izvestiya Akad. Nauk S.S.S.R.* [see above abstracts : in Russian], No. 4, Vol. 7, 1943, pp. 99–113.)

A brief survey is given of previous investigations of the subject by various authors. The case of vertical radiation is then considered and a general mathematical method is proposed in which the required function is replaced by another derived by a suitable integration of the first. A concrete example is then discussed of the propagation from a vertical radiator between two concentric spheres (earth and Heaviside layer) on the assumption that the dielectric constant ϵ of the atmosphere varies in inverse proportion to the square of the distance from the centre of the earth. The mathematical side of the problem is greatly simplified thereby, since the Bessel and Hankel functions are thus eliminated from the solution. At the same time the physical meaning of the solution is not much affected by the assumption, since ϵ does not vary by more than a few per cent from the surface of the earth to the reflecting layer (5% to 6% when the height of the reflecting layer is of the order of 150 km) ; that is to say, ϵ can be regarded as practically constant with respect to the altitude. Moreover it appears that the solution so obtained can be represented in a form analogous to Kenrick's solution (ref. " 5 " and 1928 Abstracts, p. 578) for the case of a radiator between two parallel conducting planes or concentric spheres.

The wave propagation from an arbitrary (not necessarily vertical) system of radiators, and with an arbitrary relationship between the dielectric and conductivity constants of the atmosphere and the altitude, is then considered. It is shown that an equation for the radial component of the electric field can be derived for this case not containing any other components of the electric or magnetic field. A general method is proposed for solving this equation by reducing it to an ordinary differential equation of the second order with variable coefficients.

397. THE REFLECTION OF RADIO IMPULSES FROM THE IONOSPHERE.—V. L. Ginsburg. (*Izvestiya Akad. Nauk S.S.S.R.* [*see* above abstracts : in Russian], No. 4, Vol. 7, 1943, pp. 114–133.)

A formula is quoted (top of p. 114) which is normally used for determining the time delay of reflected signals : *i.e.*, the time after which a signal radiated vertically returns to earth. It is pointed out, however, that the concept of the time delay requires further elaboration, since the amplitude of the reflected signal takes time to build up. On the other hand the time delay, as well as the time of building-up of the amplitude and the distortion of the signal, depend upon the properties of the reflecting layer, which in their turn depend on the shape of the signal.

The above points are discussed in two sections of the present paper under the following headings :—(1) The reflection of impulses from a non-uniform ionised layer, and (2) the effect of the earth's magnetic field on the reflection of radio waves. These two sections give the premisses and conclusions of two detailed investigations published by the author elsewhere : *see* 2296 of 1943 and *Journ. of Exp. & Theoret. Phys.* [in Russian], Vol. 13, 1943, p. 1 onwards : the second paper appears also in *Journ. of Phys.* [of USSR], in 1943 or 1944, probably in English.

Finally it is pointed out that for further study of the ionosphere it will be necessary to make use of reflected impulses, and that in this respect the greatest promise is held out by the interference method developed by Mandelstam & Papalexi : *see*, for example, 3103 of 1938 & back reference, and 1405 of 1940.

398. ON CERTAIN PROBLEMS IN THE PHYSICS OF IONOSPHERIC AND GEOMAGNETIC DISTURBANCES, AND ON THE EQUIVALENT PROBLEMS IN ASTROPHYSICS. — M. N. Gnevyshev. (*Izvestiya Akad. Nauk S.S.S.R.* [*see* above abstracts : in Russian], No. 4, Vol. 7, 1943, pp. 134–144.)

It has been established by many observers that there is an 11-year cycle, with 27-day recurrence, in the variations of the critical frequency f_{F_2}, the maximum frequency at which a radio wave can be reflected from the F_2 layer for a given electron density of the ionosphere. This is an indication that ionospheric disturbances are caused by processes on the sun. It has also been established that these disturbances are related to variations in the magnetic field of the earth. The relationships between these phenomena, however, and the laws governing the appearance and course of the disturbances, have not yet been clarified. Accordingly, a study is here presented in which use is made of the following experimental data :—daily and hourly observations of the ionosphere at Tomsk (Lat. 56°), Slutsk (Lat. 60°), and Tikhaya Bay in Franz Joseph Land (Lat. 80°) during 1938/1941, and observations at Washington (Lat. 39°) during 1934/1941.

So far, the following conclusions have been reached :—(1) The eleven-year variation of f_{F_2} relative to the values in 1939 is the same in all latitudes. (2) The variation of the annual mean of f_{F_2} is determined by variations in solar activity. (3) The "normal-day" value of f_{F_2} (corresponding to an "undisturbed" sun), relative to the values in 1939, is 0·6.

(4) It is possible to distinguish between the corpuscular and ultra-violet actions on the ionosphere. The first action takes place mainly at high latitudes and causes an apparent decrease in f_{F_2} and interruptions in radio communications due to increased dispersion. The second action can be observed over the whole illuminated side of the earth, and causes an increase in f_{F_2} and interruptions in radio communications owing to increased absorption in the lower layers.

(5) Geomagnetic disturbances coincide with decreased critical frequencies having values below 0·6. This indicates the corpuscular origin of geomagnetic disturbances. (6) The geomagnetic storms accompanied at high latitudes by decreased f_{F_2} are caused by narrow corpuscular beams radiated from regions of the sun's surface with specially high sunspot activity and directed towards the earth. (7) Increases in f_{F_2} are caused by increased ultra-violet radiations from active regions of the sun's surface, two months (on an average) after an increase in the sunspot activity in these regions.

399. ON SECONDARY LIGHT SCATTERING IN THE ATMOSPHERE, AND ON POLARISATION ANOMALIES DURING TWILIGHT [and Their Relation to the Electrical Properties of the Ionosphere].—V. L. Ginsburg & N. N. Soboleff. (*Comptes Rendus* (*Doklady*) *de l'Acad. des Sci. de l'URSS*, 30th Aug. 1943, Vol. 40, No. 6, pp. 223–225 : in English.)

For previous work *see* 1108 of 1944, and *cf.* Gauzit & Grandmontagne, 3789 of 1944. "For altitudes smaller than 150 km, polarisation anomalies can certainly not be associated with ionic layers. However, a correlation with the critical frequency is particularly conspicuous for layer E (ref. "1" [and 1108 of 1944]). Hence it follows univocally that the relation between the two phenomena is no direct, but rather an indirect one.

"This relation is most probably determined by some dynamical processes in the atmosphere, whose effect was both upon the concentration of ions in the layer E and upon the distribution and movement of air masses on which primary and secondary scattering takes place. For altitudes of about 200 km and above, polarisation may be affected by the variation of atmosphere composition (ions, electrons, etc.) directly. However, in this case, too, the influence can be but a secondary one. This is evidenced both by the presence of anomalies at smaller heights, where we are sure not to deal with any change in the composition, and by a number of other considerations as well.

"At considerable altitudes (ref. "5") polarisation [*sic*] becomes so insignificant that it cannot possibly be taken to account for such a degree of polarisation, whatever the change in composition.

"Along with a decrease in polarisation there takes place also rotation of the polarisation plane (ref. "5"). If we were to assume, which is quite natural, that we have in this case to deal with a rotation of the plane of polarisation of scattered light, this effect would point to an asymmetrical illumination of the scattering volume of the atmosphere. An asymmetry of this kind might take place, if (*e.g.*) the solar rays would bend, or if the scattering layer would receive more light on the one side from the plane of the vertical than on the other, etc. In the case of an illumination symmetrical with respect to the plane of the vertical, the existence of an ionic layer would at any rate not lead to the rotation of the polarisation plane.

"The problem as to the processes in the stratosphere that call forth polarisation anomalies (non-monotonous polarisation, rotation of the polarisation plane) and act upon the concentration of ions above the spot of observation is certainly of great interest."

400. A DAILY RECORD OF ULTRA-VIOLET SOLAR AND SKY RADIATION IN WASHINGTON, 1941 TO 1943 [including the Instruments & Methods used].—W. W. Coblentz & R. Stair. (*Journ. of Res. of Nat. Bur. of Stds.*, July 1944, Vol. 33, No. 1, pp. 21–44.) For previous work *see* 3256 of 1943.

401. SCATTERED RADIATION OF CLOUDLESS SKY [and the Relation between Magnitude of Integral Flow of Scattered Radiation of Atmosphere & Data of Measurements of Intensity of Solar Radiation].—N. N. Kalitin. (*Comptes Rendus* (*Doklady*) *de l'Acad. des Sci. de l'URSS*, 20th June 1943, Vol. 39, No. 8, pp. 303–305 : in English.)

For previous work *see* 2856 of 1944, and for a Note on the "Ratio between Solar and Scattered Illumination for Cloudless Sky" *see* issue for 20th July 1943, Vol. 40, No. 2, pp. 58–60.

402. SOURCES OF SKY BRIGHTNESS AND OF LANDSCAPE ILLUMINATION DURING THE TOTALITY OF A SOLAR ECLIPSE [Part played by Corona Light is Very Insignificant : Other Sources must be Present].—N. N. Sytinskaya. (*Comptes Rendus* (*Doklady*) *de l'Acad. des Sci. de l'URSS*, 30th June 1943, Vol. 39, No. 9, pp. 348–350 : in English.)

403. ON THE STRUCTURAL FEATURES OF THE SOLAR CORONA OF 21ST SEPTEMBER, 1941.—B. Fessenkoff. (*Comptes Rendus* (*Doklady*) *de l'Acad. des Sci. de l'URSS*, 20th June 1943, Vol. 39, No. 8, pp. 296–298 : in English.) For previous work *see* 2855 of 1944.

404. SOLAR RADIATION OBSERVATIONS AND VOLCANIC DUST [Summary of a Paper "Smithsonian Pyrheliometry and the Andean Volcanic Eruptions"]. — L. B. Aldrich. (*Nature*, 4th Nov. 1944, Vol. 154, No. 3914, pp. 583–584.)

405. A SOLAR HALO PHENOMENON, *and* ABNORMAL PARANTHELIA.—V. Vand, R. Holdsworth : P. White. (*Nature*, 21st Oct. 1944, Vol. 154, No. 3912, p. 517 : pp. 517–518.) For previous correspondence *see* 16 of January. The possible connections with blast phenomena, orienta-

tion of ice crystals by acoustic waves, aircraft condensation trails, etc., are discussed.

406. ON THE ORIGIN OF THE ZODIACAL LIGHT.—B. Fessenkoff. (*Comptes Rendus (Doklady) de l'Acad. des Sci. de l'URSS*, 30th June 1943, Vol. 39, No. 9, pp. 342–344 : in English.)

"Consequently, the dynamical theory of the Zodiacal Light can account for its principal features. The further working out of the theory must take into consideration the pressure of radiation." *See* also 1498 of 1944.

407. SUMMARY OF EARTH-CURRENT RECORDS FROM TUCSON, ARIZONA, FOR A COMPLETE SUNSPOT-CYCLE.—W. J. Rooney. (*Terr. Mag. & Atmos. Elec.*, Sept. 1944, Vol. 49, No. 3, pp. 147–157.)

"At most stations where earth currents have been investigated, the seasonal changes are chiefly changes in intensity, accompanied by only minor shifts in phase or in the phase-relationship between the two components. Such changes are readily described quantitatively. Tucson, however, is located in the so-called transition belt where the diurnal variations of the magnetic elements pass from higher-latitude to equatorial type as the centres of the circulatory current-systems in the ionised layers of the upper atmosphere are alternately north (summer) and south (winter) of a given station. For this reason the seasonal changes in earth-current flow are also much more complex and less readily described and evaluated" [one anomaly recurring regularly each year at Tucson has the result that the amplitude of the eastward component attains its maximum value for the year during January, "a fact quite out of line with general theory on the relation between activity and position of the sun"].

The writer remarks: "Since the records cover a full sunpot-cycle and are quite complete and homogeneous, it is believed that they afford exceptionally useful material for further study of the relationship between magnetic variations, earth currents, and the conditions existing in the ionised layers of the upper atmosphere."

408. NEXT PERIOD OF SUNSPOT MAXIMUM WILL PROBABLY COME EARLY [before May, 1948].—W. Gleissberg. (*Sci. News Letter*, 9th Sept. 1944, Vol. 46, No. 11, p. 169.) From Istanbul University Observatory.

409. LONG DURATION OF THE BALMER SPECTRUM IN EXCITED HYDROGEN.—Rayleigh. (*See* 604.)

410. IONISATION IN ACTIVE NITROGEN [Continuation of the Work dealt with in 3396 of 1944 & Back Reference], *and* VARIATIONS IN THE AFTER-GLOW BRIGHTNESS OF ACTIVE NITROGEN UNDER VARIED EXPERIMENTAL CONDITIONS [Comparison of Rayleigh's Results with the Writer's Hypothesis].—S. K. Mitra. (*Sci. & Culture* [Calcutta], Sept. 1944, Vol. 10, No. 3, pp. 133–134 : *Nature*, 4th Nov. 1944, Vol. 154, No. 3914, pp. 576–577.)

411. RELATION BETWEEN MAGNETIC STORMS AND SOLAR ACTIVITY [Summary of Canberra Paper (*Mon. Not. Roy. Astron. Soc.*, Vol. 104, 1944) describing Statistical Investigation of Influence of Solar Flares & Sunspots on Terrestrial Magnetic Storms (1906/1942): the Bartels "*M*-Regions" & Their Emission: Close Relation between Sunspots & Coronal Plumes: etc.].—C. W. Allen. (*Nature*, 21st Oct. 1944, Vol. 154, No. 3912, p. 520.)

412. A SURVEY OF METHODS OF CONSTRUCTING MAGNETIC CHARTS.—A. Bernstein. (*Terr. Mag. & Atmos. Elec.*, Sept. 1944, Vol. 49, No. 3, pp. 169–180.)

413. LIST OF GEOMAGNETIC OBSERVATORIES AND THESAURUS OF VALUES: VI [with Some Comments on the Improvement of Recording & Reduction of Data at Magnetic Observatories].—J. A. Fleming & W. E. Scott. (*Terr. Mag. & Atmos. Elec.*, Sept. 1944, Vol. 49, No. 3, pp. 199–205 : to be contd.)

414. SOME EARLY CONTRIBUTIONS TO THE HISTORY OF GEOMAGNETISM: VII—JOÃO DE CASTRO.—H. D. Harradon. (*Terr. Mag. & Atmos. Elec.*, Sept. 1944, Vol. 49, No. 3, pp. 185–198.) For a letter from L. Espenschied on Otto von Guericke's ideas and on a 1717 paper on the "magnetical" properties of piezoelectric tourmalin *see* pp. 207–208.

415. ON THE PROBLEM OF UNSTATIONARY DISTRIBUTION OF AIR TEMPERATURE NEAR THE UNDERLYING SURFACE [Treatment on Assumption that the Influx of Long-Wave & Short-Wave Radiation to Unit Earth Surface is Known].—M. Shvez. (*Comptes Rendus (Doklady) de l'Acad. des Sci. de l'URSS*, 10th Aug. 1943, Vol. 40, No. 4, pp. 144–147 : in English.)

416. PERIODIC PROPERTIES OF THE SEMI-PERMANENT ATMOSPHERIC PRESSURE SYSTEMS.—H. J. Stewart. (*Quart. Applied Math.* [Brown University], Oct. 1943, Vol. 1, No. 3, pp. 262–267.)

"It is believed that this is the first time that atmospheric motions have been discussed which have a period of the order of magnitude of, but different from, a year. Since the weather shows large variations from one year to another, it is apparent that such motions must exist; and, since the non-seasonal variation of the only external parameter, the solar-energy input, is very small, these long-period motions must be explainable in terms of the free oscillations of the earth's atmosphere . . . It is suggested that the present calculations may prove useful as a guide for the statistical analysis of empirically obtained data."

417. A HYDRODYNAMICAL THEORY OF PRESSURE AND TEMPERATURE WAVES AND OF CENTRES OF ATMOSPHERE ACTION [in connection with Long-Range Weather Forecasts].—E. N. Blinova. (*Comptes Rendus (Doklady) de l'Acad. des Sci. de l'URSS*, 10th June 1943, Vol. 39, No. 7, pp. 257–260 : in English.)

418. LONG-RANGE WEATHER FORECASTING [Summary of 12th Arthur Lecture, on the Lecturer's Method based on Study of Variations in Solar Radiation: Some Results].—C. G.

Abbot. (*Sci & Culture* [Calcutta], Aug. 1944, Vol. 10, No. 2, p. 79.) *See*, for example, 3401 of 1944.

419. A NEW METHOD OF DETERMINING THE FRACTION OF ELECTRONS IN COSMIC RADIATION [Direct Cloud-Chamber Method, with Advantages over Cloud-Chamber & Magnet Method and Indirect Counter Method].—R. R. Brown. (*Phys. Review*, 1st/15th Sept. 1944, Vol. 66, No. 5/6, p. 161 : summary only.)

420. THE SPIROTRON [for stopping Very-High-Speed Particles, using Potential Gradients applied in Successive Steps as in the Cyclotron (3800 of 1944) but avoiding Correspondingly High Frequencies of Field-Reversal].—L. E. Dodd. (*Phys. Review*, 1st/15th Sept. 1944, Vol. 66, No. 5/6, p. 160 : summary only.) *Cf.* also 549, below.

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY

421. RADIO NOISE : INTERFERENCE DUE TO NATURAL CAUSES. — T. W. Bennington. (*Wireless World*, Nov. 1944, Vol. 50, No. 11, pp. 335–338.)

Set noise : atmospherics : propagation of the noise : noise zones : noise in temperate regions : rain atmospherics (" precipitation static ") : Jansky noise : overcoming radio noise.

422. THE APPARENT BREAKDOWN OF MEEK'S STREAMER CRITERION IN DIVERGENT GAPS DUE TO THE FAILURE OF TOWNSEND'S IONISATION FUNCTION.—L. H. Fisher & G. L. Weissler. (*Phys. Review*, 1st/15th Sept. 1944, Vol. 66, No. 5/6, pp. 95–102.)

423. EVALUATION AND INTERPRETATION OF THE COLUMNAR RESISTANCE OF THE ATMOSPHERE.—O. H. Gish. (*Terr. Mag. & Atmos. Elec.*, Sept. 1944, Vol. 49, No. 3, pp. 159–168.)

" The chief significance of this comparison [bottom of p. 167] is that it indicates a reasonably satisfactory quantitative relation between the observations of gradient, of cosmic-ray intensity, and of nuclei-concentration at a given level in the atmosphere, and illustrates a method, with a reasonable physical basis, of analysis and interpretation of such data . . ."

Incidentally, the writer reports sudden field-changes of from 10 to 20 volts, measured on an elevated (4000 ft) plateau and due apparently to a local convectional thunderstorm about 100 miles away—so far that field-changes of this order could not be attributed to any of the simpler electrical models of the thunderstorm (for example the bipolar type). Similar results were obtained at the Huancayo observatory. No reports by other investigators of comparable field-changes at such distances are known to the writer : such effects may be more pronounced at high-altitude stations. They can presumably be attributed to an electric charge-distribution in the higher atmosphere, the charge being " bound " to the charge in the cloud prior to the discharge of the latter, and then being free to establish a field-component over a considerable area about the storm-centre. The rate of decay of these field-changes corresponds to that for a charge at an altitude of not more than 10 to 20 km in the atmosphere.

424. IMPULSE CHARACTERISTICS OF ELECTRICAL CONNECTIONS TO THE EARTH.—J. R. Eaton. (*Gen. Elec. Review*, Oct. 1944, Vol. 47, No. 10, pp. 41–50.)

" The previous work on impulse ground testing shows quite conclusively that under the influence of impulse currents the soil in the vicinity of a ground electrode behaves like a non-linear resistance. Because of the complexity of the current flow-line pattern within the soil volume, it has been impossible to arrive at any definite conclusions relative to the phenomena within the soil which results in this non-linear characteristic.

" In setting up a programme of test to be carried out at Purdue University it was decided to make the studies somewhat more fundamental than had been done by investigators in the past, and to begin with an investigation of the characteristics of soil when subjected to currents of known value having known flow paths through the soil. By making the soil samples of relatively small size, the difficulties of measurement mentioned in the previous paragraph were eliminated. Hence, this study became one of investigating the characteristics and behaviour of soil as a material for carrying impulse currents . . ."

425. THE ELECTRIC HYGROMETER STRIP [Treated Plastic Strip to replace Human Hair in Radiosondes (doing away with Several Moving Parts)].—J. P. Friez Company. (*QST*, Aug. 1944, Vol. 28, No. 8, p. 11 : paragraph only.) For the need for an improved way of measuring relative humidity *cf.* 3412 of 1944.

PROPERTIES OF CIRCUITS

426. FORCED TORSIONAL VIBRATIONS OF AN ELASTIC HALF-SPACE : I & II [Treatment using Oblate Spheroidal Coordinates].—Reissner & Sagoci. (*See* 472.)

427. THE DISTORTION OF FREQUENCY-MODULATED OSCILLATIONS IN THE OSCILLATORY CIRCUIT. —Wilde. (*See* 455.)

428. THE PRODUCTION OF NON-LINEAR DISTORTION BY FILTERS IN AMPLITUDE MODULATION.—Kulp. (*See* 456.)

429. BAND-WIDTH REGULATION OF FILTERS [including Quartz Filters].—Herzog. (*See* 463.)

430. THE MOUNTING AND FABRICATION OF PLATED QUARTZ CRYSTAL UNITS, *and* EFFECTS OF MANUFACTURING DEVIATIONS ON CRYSTAL UNITS FOR FILTERS.—Greenidge : D'heedene. (*See* 522.)

431. NOTES ON ELECTRO-MECHANICAL EQUIVALENCE [and the Use of Electric Filter Design Technique for Mechanical Problems].—Jefferson. (*See* 623.)

432. POWER-SUPPLY DESIGN : THE PRINCIPAL FACTORS INVOLVED IN THE REDUCTION OF RIPPLE.—G. E. Hamilton. (*QST*, Aug. 1944, Vol. 28, No. 8, pp. 26–28.)

433. FORMULAS FOR THE FOUR-TERMINAL-NETWORK PARAMETERS OF UNIFORM LADDER NETWORKS [and Smooth Transmission Lines].—W. R. Le Page. (*Elec. Engineering*, Aug.

1944, Vol. 63, No. 8, Transactions pp. 604–608.)

A summary was referred to in 3436 of 1944. "The theory of smooth lines and recurrent ladder networks is usually given in terms of the surge impedances (two, in the case of a non-symmetrical network) and the propagation function. However, this is an artificial point of view when one is interested in the over-all behaviour of the network, the parameters of equations 1 [$E_s = AE_r + B'I_r, I_s = C'E_r + DI_r$] being more suitable . . . The *A-B-C-D* parameters may be given as power-series expansions of the variable α, where $\alpha^2 = Z_T Y_T$ and Z_T and Y_T are the respective total series impedance and shunt admittance. For the smooth line these are infinite series; but they are terminating series for the ladder network, the number of terms and the coefficients of the terms being functions of the number (M) of elementary pi or T sections of which the network is composed. Formulas for these coefficients are developed and they are given in several alternate forms.

"Also included are recurrence formulas and some relations among the coefficients of the different parameters. One form for the coefficients is particularly interesting because it shows that each coefficient for the ladder network is the corresponding smooth-line coefficient multiplied by a polynomial consisting of unity plus a polynomial in non-zero powers of $1/M^2$. This puts in evidence the manner in which the two coefficients approach each other as M increases; and also leads to easily computable upper and lower bounds of the ladder-network coefficients, which may provide useful estimates of their magnitudes." The results of the work are easily extended to give a simple method of finding the zeros and poles so important in circuit analysis.

434. An "Unterminated" Line [Incorrect Use of Word "Unterminated" to denote Open-Circuited or Open-Ended].—G. W. O. H. (*Wireless Engineer*, Dec. 1944, Vol. 21, No. 255, p. 559.)

435. On the Foundations of Electrical Network Theory: Parts I & II.—W. H. Ingram & C. M. Cramlet. (*Journ. of Math. & Phys.* [of M.I.T.], Aug. 1944, Vol. 23, No. 3, pp. 134–144: pp. 144–155.)

(i) "Part I essays an orderly arrangement of some elementary topological ideas in combination with some analytical ones of an essentially dynamical nature. A combination of the simplest examples from these two classes of ideas first appeared in the work of Kirchhoff, and subsequent development of the theory of electrical networks has been, in fact if not in statement, an amalgamation of the two mathematical sciences. But the elementary theory, up until the present, has been incomplete in one particular, or at least has required clarification; namely in regard to the implication of the circuital flow of electricity from Kirchhoff's Second Law. This defect is removed in Theorem 4, where it is proved that the chord currents for any tree in the graph of a network have circuital properties . . ."

(ii) The first and second incidence matrices of a connected sagittal graph: generalisation of the circuital flow theorem: dependent equations on independent circuits.

436. Networks with Predetermined Network Matrices [Conclusion of 1537 (and 1891) of 1944].—W. Bader. (*T.F.T.*, July 1943, Vol. 32, No. 7, pp. 144–147.)

437. "Electric Circuits and Fields" [Book Review].—H. Pender & S. R. Warren. (*Gen. Elec. Review*, Sept. 1944, Vol. 47, No. 9, p. 62.) "A very valuable aspect . . . is that the applications of the theory are kept before the reader throughout . . ."

438. Symmetrical Components [and the Use of the Magnetic Oscillograph in studying the Basic Relations in the Symmetrical-Component Method of Analysing Complex Circuits].—R. W. Ahlquist. (*Gen. Elec. Review*, Oct. 1944, Vol. 47, No. 10, pp. 22–27.)

439. Correction to "Direct Reading of the Frequency of Resonant Circuits."—Griffiths. (*See* 527.)

440. Mathematical Analysis of Random Noise: Part I—Shot Effect: Part II—Power Spectra and Correlation Functions.—S. O. Rice. (*Bell S. Tech. Journ.*, July 1944, Vol. 23, No. 3, pp. 282–332.)

Parts III & IV will deal with "Statistical Properties of Noise Current" and "Noise through Non-Linear Devices": but long summaries of the principal results are included in the present paper (pp. 287–294).

"The random noise considered is that which arises from shot effect in vacuum tubes or from thermal agitation of electrons in resistors. Our main interest is in the statistical properties of such noise and we leave to one side many physical results of which Nyquist's law may be given as an example (*see* Moullin's book, 1914 of 1939). About half of the work given here is believed to be new, the bulk of the new results appearing in Parts III and IV . . ."

441. Wide-Band Amplifiers for Measuring Purposes, for Very Large Frequency Ranges.—R. Wunderlich. (*E.N.T.*, Nov./Dec. 1943, Vol. 20, No. 11/12, pp. 264–270.)

For the investigation of small alternating-voltage signals, which may be regarded as made up of a spectrum of sinusoidal components, an amplifier must transmit all these components correctly as to amplitude and phase (and consequently as to time), so that the synthesis of all the amplified components may reproduce the signal in its correct form in an amplified state. The most elementary and most generally employed type of amplifier is the resistance–capacitance stage of Fig. 2. At medium frequencies this circuit functions correctly as regards amplitude, and the frequency/phase-angle characteristic is linear: it is worth noting that even a small amplitude error is accompanied by a marked departure of the phase characteristic from linearity, so that for a strict test the phase characteristic is the better criterion.

At low frequencies a drop in amplitude appears and a phase rotation towards positive values, due to the coupling capacitor K, which is really only necessary for keeping out the d.c. voltage. At high frequencies the unwanted valve and circuit capacitances produce a drop in amplitude and a phase rotation towards negative values. Amplitude drop and phase angle are rigidly interconnected; a definite angle ϕ corresponds to an error p [*cf.* 1926 of 1942]. The symmetry of the curve leads to the result that for equally large drops at the high and low frequencies the absolute angles of displacement are equal. The frequency characteristic (regarding amplitude and phase) of the voltage-transmission of an elementary *RC* amplifier is similar to that of an oscillatory circuit damped by series and parallel resistances, Fig. 3 [*cf.* 1927 & 3526 of 1942].

Many papers have already appeared dealing with the exact calculation of the *RC* amplifier and its elements for predetermined limiting frequencies, and data-charts provide a simple means of designing such circuits. The writer does not concern himself with these; his object is to investigate the possible extension of the frequency range both upwards and downwards, without affecting the degree of amplification.

He deals first with the low frequency limit, given by the time constant $R_g K$ of the grid circuit (Fig. 4), and the problem of lowering it; beginning with a discussion of the difficulty, encountered with the usual circuit, due to resistance noise, hum, and parasitic voltages existing in the anode supply. The superiority, in this respect, of the triode over the pentode is discussed. But the right-hand circuit of Fig. 5 to a large extent avoids the difficulty, for both types of valve. Here the working resistance ($R = 1$ kΩ), which in the ordinary circuit (same figure, left-hand) is in the first anode circuit, has been transferred to the grid circuit of the second valve, the original 50 kΩ grid resistance taking its place in the lead to the first anode. The great noise-reducing properties of this arrangement are discussed, and it is shown how a still further modified circuit (Fig. 6, right-hand), with a capacitance C_g (shunted by a 1 kΩ leak) introduced between the 1 kΩ resistance (now in the second-valve grid circuit) and the earth connection, will under suitable conditions not only reduce the effect of a noise voltage in the anode supply (in some circumstances down to 4%) but also lower the bottom frequency limit by a factor of 25.

The upper frequency limit, on the other hand, can be raised by a factor of about 10 by a modification of Wheeler's plan (Figs. 9, 10 : 3517 of 1939) of combining the unwanted valve capacitances with inductances to form a series of " pi " networks. The modified circuit, in which the filter chain is made into a four-pole impedance instead of its original two-pole form, is seen in Fig. 11.

Finally, Fig. 12 gives the circuit combining the two plans of Figs. 6 and 11 and thus extending the frequency range both downwards and upwards. For previous work, in addition to the papers cited above, *see* 2524 & 3128 of 1944.

442. CORRESPONDENCE ON " GEOMETRY OF PUSH-PULL AMPLIFICATION " [3821 of 1944].—D. A. Bell : Russell. (*Wireless Engineer*, Dec. 1944, Vol. 21, No. 255, p. 584.)

" I believe the general criterion is that the valve anode current should be a function of grid voltage of not higher than second degree ; for perfectly matched valves this may be demonstrated as follows . . . The great practical advantage of Mr Russell's hyperbolic representation is that it allows the anode current to approach zero asymptotically . . . and this is likely to facilitate the analysis of actual valve characteristics."

443. " WILLANS OSCILLATOR CIRCUIT " : A CORRECTION.—E. A. Hanney. (*Wireless World*, Nov. 1944, Vol. 50, No. 11, p. 351.) *See* 3826 of 1944.

444. THE INFLUENCE OF THE DYNAMIC INTERNAL RESISTANCE AND OF THE DAMPING ON THE SELF-EXCITATION OF ELECTRICAL OSCILLATIONS IN BACK-COUPLED VALVE GENERATORS.—Bohnenstengel. (*See* 457.)

445. CONTRIBUTION TO THE THEORY OF SYNCHRONISATION OF RELAXATORY AUTO-OSCILLATIONS.—K. Theodorchik. (*Comptes Rendus* (*Doklady*) *de l'Acad. des Sci. de l'URSS*, 20th July 1943, Vol. 40, No. 2, pp. 54–57 : in English.)

The systems considered here are such that the discharge is so rapid compared with the charge that its duration may either be neglected or regarded as constant and independent of the external influences upon the system : a simple neon-tube circuit is taken as an example. Equations 11 and 12 are obtained for such a system when under the influence of an external periodic force $e(\phi)$: these are $\psi_n = f_2 \{R, C \ldots e(\phi_n - \alpha)\} + \alpha - f_1 \{R, C \ldots e(\phi_{n-1})\}$ and $\phi_n = \psi_n + \phi_{n-1}$. " It may be seen from these formulae that auto-oscillations are no longer isochronous if some parameter determining the period is modulated by the external periodical influence. Then the duration of each period is uniquely determined by the phase value of the external force at the start of its application.

" Isochronous auto-oscillations cannot possibly take place in the presence of an external periodical force unless $\phi_n = \phi_{n-1} = \phi_0$ holds within $2\pi N$; *i.e.* $\psi = 2\pi N$, $\tau = NT$, $N = 1, 2, 3 \ldots$ In other words, the occurrence of isochronous auto-oscillations under a periodical influence applied externally may only be observed on the condition that the auto-oscillations are synchronised by the external force.

" We shall now prove that if in the absence of an external force the period of auto-oscillations ψ_0 is near enough to $2\pi N$, then when the external force is present the sequences ψ_n and ϕ_n will tend with increasing n to one of the above-mentioned synchronous régimes of order N, as a limit . . ." Other results relate to the influence of the amplitude of the external synchronising force : thus after a certain critical value has been reached, the condition $(d\psi/d\phi)_0 < 1$ breaks down : " on the boundary of synchronisation bands in the areas where this condition is disturbed, there may take place a periodical convergence of the sequence of values assumed by the period " : this applies also to the synchronisation of the first undertone $N = \frac{1}{2}$.

446. SOME PRESENT NON-LINEAR PROBLEMS OF THE ELECTRICAL AND AERONAUTICAL INDUSTRIES.—E. G. Keller. (*Quart. Applied Math.* [Brown University], April 1944, Vol. 2, No. 1, pp. 72–86.) *See* also 447, below.

447. THE ENGINEER GRAPPLES WITH NON-LINEAR PROBLEMS [Josiah Willard Gibbs Memorial Lecture].—T. von Kármán. (*Bull. Am. Math. Soc.*, Vol. 46, 1940, p. 615 onwards.) Referred to in Keller's paper (446, above) : " both a milestone and a beacon of progress . . ." For another paper *see* 3036 of 1944.

448. LETTER ON " SOME ASPECTS OF INDUCTANCE WHEN IRON IS PRESENT " [3840 of 1944 : Suggested Use (with Examples) of Power-Series Method of Treatment].—A. F. Puchstein : Rader & Litscher. (*Elec. Engineering*, Aug. 1944, Vol. 63, No. 8, pp. 320–321.)

449. A Note on Inductance Variation [with Core Position] in R.F. Iron-Cored Coils.—T. R. W. Bushby. (*A.W.A.Tech. Review*, Aug. 1944, Vol. 6, No. 5, pp. 285–290.)

Inductance measurements were made on a number of experimental and production coils, by resonating the coil on a Q-meter, for various positions of the core as it was moved by small increments on either side of the position for maximum inductance L_i: the change of inductance caused by the presence of the core (expressed as a fraction of the maximum change obtained) was plotted as a function of the core displacement.

It was found that the resulting curve bore a striking resemblance to the curve of the normal probability law of statistics, $M = e^{-x^2/2\sigma^2}$, and by a suitable choice of parameters the latter curve could be made to fit the experimental points with great accuracy (Fig. 1). Now Foster & Newlon's paper (3462 of 1941) provides the necessary information for obtaining L_i when μ is known, and L_o can be derived reliably from the coil geometry: hence if σ, the statistical "standard deviation", could be predetermined, complete information would be available for the initial theoretical design of iron-cored coils without any experimental work.

Examination of the data obtained did not disclose any simple correlation between σ and any of the coil characteristics, but the figures available suggest that σ tends to be constant, and for coils generally similar to those listed may be taken, for initial design purposes, as 0.31 inch.

450. A New High-Frequency Capacitor [with Low Impedance over a Wide Frequency Range].—W. M. Allison & N. E. Beverly. (*Elec. Engineering*, Aug. 1944, Vol. 63, No. 8, p. 312: summary only.)

"That effects due to inherent inductance of the conventional two-terminal capacitor have been overcome by the operation of this improved capacitor as a transmission line is evidenced by the complete absence of resonant effects in the range studied. It is a three-terminal network used most efficiently in the same manner as the low-pass filter. In physical appearance and size the new capacitor is similar to conventional capacitors of the same l.f. capacitance and voltage rating. These novel characteristics can be used advantageously over a wide frequency range to filter or by-pass r.f. noise from d.c. or l.f. current circuits, as circuit elements in conventional filters, and to by-pass multi-band receivers and transmitters."

451. Potentiometer Rheostats [Formulae & Graphs].—G. W. Stubbings. (*Electrician*, 1st Dec. 1944, Vol. 133, No. 3470, pp. 489–490.)

TRANSMISSION

452. Electric Vibrations in Particles of a Mass-Radiator.—A. A. Glagoleva-Arkadieva & A. P. Kalugina. (*Comptes Rendus (Doklady) de l'Acad. des Sci. de l'URSS*, 20th Sept. 1943, Vol. 40, No. 8, pp. 306–308: in English.)

For earlier work *see* 1930 Abstracts, p. 158. Kalugina's experimental results (refs. "2", "3"), with a mixture of aluminium filings and machine oil, are compared with the first writer's theory (2106 of 1943), and the measurements extended to masses containing particles of greater length, up to 0.16 cm (Kalugina's longest particles had an average length l of 0.094 cm). "The results obtained go, in the first place, to support the correctness of our interpretation of the operation of the mass-radiator; the short waves are actually generated by the electric vibrations arising in the particles of the vibrational mass; secondly, they prove that the theory of action of a mass-radiator, consisting of particles of a regular shape arranged in the dielectric medium according to a definite scheme, may be applied to a radiator in which the vibrational mass consists of moving particles of a complex and irregular shape suspended in the dielectric medium. This theory helps to explain the experimental data. Thirdly, the experimental curve (see figure) makes it possible to calculate the coefficient m [$= \lambda/a$, where $a = 2l =$ length of vibrator formed by a pair of particles] for small vibrators immersed in the vibrational mass."

453. A Receiving-Tube 112 Mc/s M.O.P.A. [Master-Oscillator / Power-Amplifier]: a WERS Transmitter using 6V6GTs [and giving 7 Watts to the Aerial—"An Output over Twice that of a Receiving-Tube High-*C* Oscillator"].—D. Espy. (*QST*, Sept. 1944, Vol. 28, No. 9, pp. 54–56.)

"Although this tube has proven its ability as an oscillator, there had been no indication of successful use of it as a r.f. amplifier at frequencies above 14 Mc/s or so . . ."

454. Frequency Modulation by means of Reactance Valves.—H. Bohnenstengel. (*T.F.T.*, March 1944, Vol. 33, No. 3, pp. 41–45.)

Author's summary:—"For determining the optimum working conditions for a linear reactance-valve frequency modulator from the viewpoint of the frequency-deviation, general quantitative design rules are given and formulae are derived, for a linear single-valve modulator, which will allow the maximum frequency-deviation to be calculated. It is shown to be more advantageous to employ, as reactance valves, pentodes with square-law characteristic and steep average slope, and to use them as a controllable inductance ["a wide distortion-free modulation with the help of a controllable capacitance C' can only be attained if the condition $C_a \gg C'$ is fulfilled. Since there is no such limitation for a controllable inductance, a comparison of the results of eqns. 7 and 8 shows that a controllable inductance will allow a larger frequency-deviation to be obtained than a controllable capacitance." At the end of p. 44 it is mentioned that a larger relative frequency-deviation can actually be obtained by the simultaneous and opposed control of a variable inductance and of a variable capacitance in parallel to it; but the frequency change will not be a linear function of the modulation amplitude. In spite of the distortion, however, such a modulator has certain advantages, which must be considered in close conjunction with conditions at the receiving end and are not dealt with here. The properties of push-pull frequency-modulators also will be considered in a later paper].

"In this case the higher-resistance voltage-divider component should be formed of a real resistance, to keep down the effect of a disturbing amplitude modulation. To obtain a large frequency-deviation the modulator must have as wide as possible a range of modulation free from grid current ; that is to say, the negative grid-blocking voltage of the reactance valve must have the highest possible value compared with the oscillation-amplitude of the generator."

455. THE DISTORTION OF FREQUENCY-MODULATED OSCILLATIONS IN THE OSCILLATORY CIRCUIT [Application of the " Line-Harp " Graphical Technique to the Processes due to Sudden or Continuous Variations of Frequency].—H. Wilde. (*T.F.T.*, July 1943, Vol. 32, No. 7, pp. 150–161.)

Feldtkeller's idea of the treatment of transient processes by the use of an equivalent circuit composed of distortionless lines (3417 of 1941) was improved on by Gensel (1442 of 1942 [and 2341 of 1943]) by the introduction of the concept of the " line harp," made up of a whole system of lines with infinitely finely divided path-time differences.

The application of this technique to the present problem furnishes a method by which the frequency distortion experienced by a frequency-modulated oscillation in an oscillatory circuit or any filter arrangement can be determined graphically, and the resulting non-linear-distortion factor calculated. The accuracy of the graphical construction is such that the lower limit of the " klirr " factor which can be derived is about 1%, corresponding to a " klirr " attenuation of about 4 nepers. The method has the advantage over numerical procedures, such as those of Carson & Fry and of Roder, that it is not limited to sinusoidal frequency modulation but can be applied to any form of periodic frequency changes.

Throughout the paper, the quantities involved are all used in their " normalised " or relative form (*see*, for example, 3530 of 1942) with respect to the oscillatory circuit : that is, they are rendered dimension-less : thus T, the " normalised " time, is t/τ, the time referred to the building-up time of the oscillatory circuit. The advantage of this plan is that the locus curves and diagrams become applicable to any such circuit whatever.

456. THE PRODUCTION OF NON-LINEAR DISTORTION BY FILTERS IN AMPLITUDE MODULATION.—M. Kulp. (*E.N.T.*, Nov./Dec. 1943, Vol. 20, No. 11/12, pp. 277–284.)

From the Telefunken laboratories. The publication of this paper has been delayed from November, 1942 : in the meantime, Böttcher's paper (2127 of 1943) has appeared. An approximate analysis has been made by Hofer (3276 of 1937), and P. P. Eckersley has dealt with the problem rather more fully in his paper on asymmetric-sideband broadcasting (312 of 1939 [*see* also 4146 of 1938]).

The present paper deals in succession with the " klirr " factors (of non-linear distortion) due to spectral intensity changes ; those due to phase changes ; and with the subsidiary frequency modulation accompanying the intensity changes and that accompanying the phase displacements. " If we take the spectrum, free from non-linear distortion, of amplitude modulation with equal sidebands, of equal phase, and make from it a system of two sidebands of unequal strength, then the modulation will be made to contain overtones and ' klirr ' factors, as shown in Table 1 and Figs. 1 and 2. The over-all ' klirr ' factors are given in Table 2 and Fig. 4. The highest values appear for the modulation coefficient $\mu = 1$ and the extreme case of single-sideband working, when they reach as much as about 12%.

" If, instead of the intensities, it is the phases of the spectral components that are affected, then the fundamental and overtone intensities will be as given in Fig. 7 and Table 3 : the ' klirr ' factors are shown in Fig. 8. Symmetrical phase displacements, such as are due to a non-linear but symmetrical phase-characteristic of a filter, produce no non-linear distortion. But with asymmetry the fundamental tone may vanish completely, so that infinitely large ' klirr ' factors may ensue.

" Simultaneously with the appearance of these overtones, a frequency modulation may occur : its calculation is given [pp. 283–284]. The resulting frequency-deviations do not, however, exceed the value of the modulation frequency ", and can therefore be considered (compared with the carrier frequency) as negligible in both cases, whether associated with intensity variations or with phase displacements.

457. THE INFLUENCE OF THE DYNAMIC INTERNAL RESISTANCE AND OF THE DAMPING ON THE SELF-EXCITATION OF ELECTRICAL OSCILLATIONS IN BACK-COUPLED VALVE GENERATORS.—H. Bohnenstengel. (*T.F.T.*, March 1944, Vol. 33, No. 3, pp. 53–55.)

The excitation of oscillations by retroactively coupled valves has been so exhaustively dealt with already that a further treatment of the problem can count on raising any interest only if it limits itself to the very shortest waves. The present paper, however, points out certain facts which, in spite of their being of general significance in the theory of oscillation, are neither covered by the known self-excitation theories nor taken into account in any of the previous publications. The problem considered is the influence of a real loss-resistance parallel to the oscillatory circuit, of a value which takes into account not only the total external load but also, and particularly, the resulting dynamic internal resistance of the generator.

The derivation of eqn. 14 indicates that in the designing of the oscillatory circuit of a back-coupled generator it is not enough, if the " aperiodic limiting case " (state of aperiodic equilibrating process) is to be avoided, to take into account merely the influence of the resulting anode resistance : an equally strong influence is exerted by the resulting dynamic internal resistance $\mathfrak{R}_i$, whose effective value in the steady state coincides with that of the effective anode resistance $\mathfrak{R}_a$.

The importance of the fact established, that the periodicity of the oscillatory process in the anode circuit is also dependent on the influence of the dynamic internal resistance of the generator, is increased by the general acceptance of the belief that a tight back-coupling, and thus (by eqn. 5) a small dynamic internal resistance, is sufficient in itself for the production and maintenance of self-excitation. Eqn. 14 shows that for a given design and loading of the generator it is not permissible to increase the back-coupling to an arbitrary degree, and that the absence of self-excitation occasionally encountered with strong back-coupling cannot be attributed merely to the effect of the grid current which sets in. " The fundamental self-excitation criterion, $-\mathfrak{R}_i \leq \mathfrak{R}_a$, which must be fulfilled for all generators of dynatron character (*i.e.*, in which the dynamic internal resistance is reached by transition through the limiting value $\mathfrak{R}_i = \infty$) is restricted in its range of validity, and in its complete form must be expressed as $-\mathfrak{R}_i$

$\leq \mathfrak{R}_a$ and $\sqrt{1/(2 . C/L - 1/W^2)} < |\mathfrak{R}_i| \leq |\bar{\mathfrak{R}}_a|$, where $\bar{\mathfrak{R}}_i$ and $\bar{\mathfrak{R}}_a$ are the mean values, in time, of the resistances which govern the transient process in the anode oscillatory circuit, and which almost exclusively have a real value."

Finally, an examination of the frequencies of the self-excited oscillation shows that the statement, derived from the usual theory, that basically "all those frequencies can be excited which can be amplified in the case of separate excitation", has only a restricted validity. "Self-excitation is only possible within the frequency limits given by eqns. 17 and 19a, b, while on the other hand a limiting of the amplifiable frequency band makes its appearance less and less, the smaller the internal resistance of the valve."

RECEPTION

458. Long-Distance "Bursts" on the Very-High-Frequency Band.—F.C.C. (*See* 390.)

459. Very-High-Frequency Radio-Noise Elimination [M.F. & H.F. Methods apply also at V.H.F: Aircraft-Engine Ignition System analysed: Fields & Coupling Paths: Outline of Test Programme, by which Each Path is Isolated: Methods for controlling the Various Paths].—T. B. Owen. (*Elec. Engineering*, Aug. 1944, Vol. 63, No. 8, p. 312: summary only.)

460. Radio-Noise Elimination in Military Aircraft.—G. Weinstein & others. (*Elec. Engineering*, Aug. 1944, Vol. 63, No. 8, p. 312: summary only.)

"Outlines a method of elimination by which a great deal of preliminary radio design work can be accomplished prior to the completion of the prototype airplane." Includes a proposed method for determining the maximum allowable conducted-radio-noise level.

461. Radio Noise: Interference due to Natural Causes.—Bennington. (*See* 421.)

462. The Interference Problem [Comments on Recent Correspondence (*e.g.* 3854 of 1944): Other Sources of Interference: Legislation needed Not merely regarding Manufacture & Sale but also for Periodic Inspection, etc.].—G. W. M. Lush. (*Wireless World*, Nov. 1944, Vol. 50, No. 11, pp. 350–351.)

"Is there a single enlightened Member of Parliament who will fight this crusade in the present welter of post-war planning? The opportunity will never return" [*cf.* "Diallist," 1915 of 1944].

463. Band-Width Regulation of Filters [in the Search for Improved Selectivity in Reception].—W. Herzog. (*T.F.T.*, April 1944, Vol. 33, No. 4, pp. 78–82.)

In broadcast-receiver band-pass filters with two or more circuits, a certain degree of band-width control is attained by variation of coupling and damping: in receiving apparatus in general, retroaction brings a certain increase in selectivity: certain quartz filters can be regulated as to band width (Kautter, 3284 of 1937 and 478 of 1938: Bechmann, 2926 of 1938). But all these methods are of limited application, and the need for adjustable band-pass filters still remains. The present writer describes a retroaction method which can be applied to any band-filter circuit and gives an extensive control of band width: it involves the use of only a single additional valve. Its application to intricate composite filters, particularly of the quartz type, is of special interest because of the previous severe limitations in the regulation of such filters.

The plan is outlined as follows:—"It is known from receiving technique how to obtain an improvement in selectivity by the use of retroaction. Thus it would be possible to take the already filtered voltage and bring it back again in front of the filter by means of a back-coupling. But this would require a back-coupling which would be independent of phase at all settings of the capacitance. Since this is possible, in practice, only within very narrow limits, a serious distortion of the selectivity curve would result. This difficulty is avoided by the use of a valve for retroaction [Fig. 1]. By a suitable choice of the anode resistance and the two coupling resistances, a sufficiently phase-independent retroaction is arrived at to provide a very satisfactory band-width regulation."

The theory is worked out and applied first to a narrow-band two-quartz filter of differential type (Fig. 3), for 127.5 kc/s, with an intrinsic band width of ± 25 c/s, which by the method in question is regulated down to ± 2 c/s. The theoretical results are well confirmed by experiment. A further narrowing of the characteristic was impossible, because oscillations set in. Another example is a wide-band (two-quartz and parallel inductances, Fig. 8) filter for 530 kc/s, whose band width was regulated continuously from its original ± 4000 c/s down to ± 250 c/s. The regulation may be symmetrical or, for a single-sideband filter, asymmetrical (*see* section 6b).

464. Regenerative R.F. Stage using 6L7 Pentagrid Mixer [for C.W. Reception & Additional Gain: Regeneration Control with No Effect on Circuit Resonance].—L. G. Genung. (*QST*, Sept. 1944, Vol. 28, No. 9, pp. 70–71.)

"Since the method of feedback is primarily that of a multivibrator . . . a wide channel is available for the reception of voice or even of music frequencies, even while the circuit is actually oscillating. The zero beat will be quite broad . . ."

465. A Multiple Antenna Coupling System: a Method of operating Several Receivers on a Single Antenna.—M. H. Kronenberg. (*QST*, Aug. 1944, Vol. 28, No. 8, pp. 9–11.)

The principal circuit discussed is one to permit simultaneous operation of three receivers covering a frequency range of 1.5 to 20 Mc/s on a single aerial, with a minimum of interference. It contains five valves (including the rectifier) and gives consistent operation over the whole range without requiring tuning or adjustment. Possible variations are discussed briefly, including a modification for the case where it is necessary to maintain a balanced transmission line.

466. A Telecontrolled Tunable Receiver Installation [Extension of Principles discussed in Previous Paper (808 of 1944) to

Operation of Pair of Tunable Receivers suitable for Marine & Other Similar Services: Control by Telephone Circuits with Earth Return: Motor-Driven Coarse Tuning, Reactance-Valve Fine Tuning].—J. E. Benson & H. A. Ross. (*A. W. A. Tech. Review*, Aug. 1944, Vol. 6, No. 5, pp. 267–283.)

467. A Sound-Operated Relay Control: a Circuit for Remote Control of Broadcast Receivers and Other Devices [operated by a Handclap or Whistle, etc.].—L. K. Conn. (*QST*, Aug. 1944, Vol. 28, No. 8, pp. 33 and 59.)

"An interesting feature of the relay [affectionately known in the household as a "commercial-eradicator"] is the [non-mechanical] method used to obtain the operate-and-release sequence as a function of successive identical sounds . . ."

468. Comparison of a 1939 Four-Valve Receiver with a 1943 Model [and the Economy in Material obtained in the Latter].—M. Adam. (*Génie Civil*, 15th July 1943, Vol. 120, No. 14, p. 159.) In an article on a Paris exhibition. *See* also 2190 of 1944.

469. "Tiny Tim": a "QSL"-Size Portable Receiver [for the 3.5 & 7 Mc/s Bands: using One 1D8GT Valve: As Much Volume as given by Two-Valve Receivers of a Few Years Ago].—P. J. Palmer. (*QST*, Sept. 1944, Vol. 28, No. 9, pp. 57–59.)

To match a transmitter described in the July issue. The diode portion of the composite valve is not used: the triode section acts as a regenerative detector, the pentode section as the a.f. amplifier.

AERIALS AND AERIAL SYSTEMS

470. A Comparison between Electric Horns and Other Directional Radiators.—O. Schäfer. (*T.F.T.*, July 1943, Vol. 32, No. 7, pp. 141–144.)

Although Barrow, Southworth, and other American workers have gone fairly thoroughly into the electric horn, their investigations left a few points open to question. Some of these have been confirmed by subsequent research, but others gave discrepancies, on further examination, of an importance not to be under-estimated in judging the value of the new type of radiator.

The absorption surface (F_{abs}) of any aerial or combination of aerials is, as is well known, defined as that surface through which, in the absence of the aerial, a plane wave transports the amount of energy which can, in optimum matching conditions, be transferred to the load resistance of the aerial. Fränz (1886 of 1943) has shown that with certain directional arrangements the quotient q of the absorption surface by the geometrical surface F may be greater than unity, although for practical reasons the increases of this quotient is subject to rather close limits.

If, with the optimum matching resistance, the converted received power of a $\lambda/2$ dipole is given the value of unity, the gain G of any directional aerial system is defined as the factor by which the received power is better than this, the optimum matching resistance in this case being, of course, different as a rule from the previous value. Finally, a directional aerial may be characterised by its radiation diagram, from which the gain can also be determined by graphical integration.

The American workers give for the horn not only the gain measured on various forms but also formulae for calculating it: as a result, the value of $q = F_{abs}/F$ is found to be practically unity, so that the horn, from whose "sharp end" the energy is taken, must be considered as an almost perfect absorber, and consequently practically no energy must flow backwards from its mouth. Now apart from the fact that orienting tests showed the presence of a reflected wave in front of the mouth, the values of gain determined from the given radiation diagrams do not agree with the measured values. Before giving his own results the present writer tabulates some values of q and $G\lambda^2/F$, theoretical or experimental, taken from papers by various workers, for the parabolic mirror (q about 3/8), the fir-tree aerial (limiting value of q, for F much greater than λ^2, 0.5), and the fir-tree aerial with reflector (limiting value for q, 1.0).

A discussion of this table, at the beginning of p. 142, brings out the fact that though $q = 1$ can be attained, it is the limiting value only obtainable by a suitable combination of two equal dipole "surfaces," while all other, "simple" arrangements have q values below 0.5: even attempts to improve the parabolic mirror by the addition of a smaller back-radiating mirror did not raise q above 0.5 (Brendel, 1776 of 1936), and according to Fränz this can only be attained by pairs of radiators in phase opposition. The writer concludes that a fundamentally different behaviour on the part of the horn is *a priori* improbable.

He then proceeds to his own treatment of the problem, beginning with an examination of a rectangular-section horn used as a transmitter, and considering it as simply the termination of a "pipeline" (Barrow, 22 of 1937) serving to match the characteristic impedance of the pipe to that of the free space. He then obtains, for symmetrical directive radiators in general, a simple approximate formula linking sharpness of directivity with gain: $\phi^2 \times G \sim 25 \times 10^3$, where ϕ is the usual "quarter-value breadth" representing the sharpness of directivity. A comparison of values thus calculated for 13 different systems, with measured results given by various authors for those particular systems, shows good agreement except in examples 2, 5, and 6 (Table II), all three from the same American paper. The present writer concludes that there was an error in calculating the gains from the measured radiation diagrams.

Finally the writer briefly describes confirmatory experiments carried out on a 14 cm wave with a zinc horn of circular cross-section. Owing to difficulties in the measurement of the un-amplified received power, the measurements were estimated as accurate only within ± 10%, but they were quite sufficient to establish the following results:—The electric horn as a symmetrical radiator is *equal* to a paraboloid-of-revolution reflector (of the same area of "mouth") so far as beaming action is concerned, but it is *inferior* as regards expenditure of material: the circular-section horn seems slightly superior to the rectangular-section horn: the chief advantage of a horn lies, for small values of gain, in its convenient matching properties and the high transfer efficiency. "With centimetric waves it is possible also to obtain, economically, high values of gain, in connection with which the advantages of the tube line over the concentric cable should make themselves felt in addition."

471. PROPOSED SYMBOLS FOR THE MODIFIED COSINE AND EXPONENTAL INTEGRALS [for Problems of Electromagnetic Radiation].—Schelkunoff. (*See* 612.)

472. FORCED TORSIONAL VIBRATIONS OF AN ELASTIC HALF-SPACE : I & II [Treatment using Oblate Spheroidal Coordinates].—E. Reissner & H. F. Sagoci : H. F. Sagoci. (*Journ. Applied Phys.*, Sept. 1944, Vol. 15, No. 9, pp. 652–654 : pp. 655–662.) For the work of Chu & Stratton, here utilised, *see* 1594 of 1942 [and *cf.* 1888 of 1941].

473. POLICE SATELLITE SYSTEM [F. M. Signals from Cars in Remote Areas automatically Relayed to Central Point : the 60° "Corner" Reflectors used to avoid Interference].—E. S. Naschke. (*Electronics*, May 1944, Vol. 17, No. 5, pp. 94–96.)

474. A SIX-ELEMENT VERTICAL ARRAY FOR 113 Mc/s [Stacked Array on the Extended "Double Zeppelin" Principle].—D. C. Wallace. (*QST*, Sept. 1944, Vol. 28, No. 9, p. 70.)

475. THE HALF-WAVE DIPOLE AERIAL [Sequel to Editorial dealt with in 26 of January : Mathematical Difficulties avoided by replacing the Cylindrical Wire by a Conical Arrangement : the *Q* Value of a Tuned Dipole (equals π divided by Attenuation Coefficient per Wavelength) : the Question of the End Capacitance *C* : etc.].—G. W. O. H : Collie. (*Wireless Engineer*, Dec. 1944, Vol. 21, No. 255, pp. 557–559.)

476. CORRESPONDENCE ON "A DIRECTIVE ANTENNA FOR THE LOWER FREQUENCIES" [2202 of 1944 : Formula given for Field Pattern is valid only if Current in Centre Element is Double that in Each End Element : etc.].—E. G. Henry, A. Preisman : Penners. (*QST*, Aug. 1944, Vol. 28, No. 8, pp. 60–61.)

477. A MULTIPLE ANTENNA COUPLING SYSTEM : A METHOD OF OPERATING SEVERAL RECEIVERS ON A SINGLE ANTENNA.—Kronenberg. (*See* 465.)

478. MATCHING CIRCUITS FOR BROADCASTING-STATION AERIALS WITH FEEDERS, AND THEIR TUNING.—I. R. Anton. (*T.F.T.*, Dec. 1943, Vol. 32, No. 12, pp. 247–258.)

Modern broadcasting stations generally have their aerial systems at a considerable distance from the transmitter building, thus reducing the effect of the radiation field on the transmitter and avoiding the danger of the building being damaged by the fall of a mast. This plan involves the use of feeders, in the form of concentric cable or single- or two-wire lines : the first is the most usually employed because of its almost complete freedom from radiation. For the reflection-free matching of the aerial to the feeder various circuits may be used (Figs. 1a & d, pure inductive coupling, capacitive coupling, both for earth-point-fed aerials—asymmetrical circuits : Figs. 1b & c, pure inductive coupling, galvanic-inductive coupling, both symmetrical circuits, used for instance with dipoles. "By mirror-image formation in the earth's surface the symmetrical connection is derived from the asymmetrical : *see* Brückmann's book" [4443 of 1939]). The comparative merits of the various coupling methods are discussed briefly, reference being made to the Cairo ruling concerning the limitation of harmonics and the advantage, from this point of view, of the capacitive coupling.

A full mathematical analysis of the various matching circuits occupies pp. 248–253, and is followed by a description of practical measuring methods used for making the matching and tuning adjustments. The first method (pp. 254–255) is based on obtaining the highest value for the ratio of secondary current to primary current. It is condemned as a long and complicated process, and the writer goes on to describe two more modern methods, one based on the use of two quotient-meters and the other on the use of two phase-bridges. The diagrams (Figs. 15, 16) relating to the former method are based on information provided by Telefunken ; those for the latter method (Figs. 17, 20) by the C. Lorenz Company.

479. IMPULSE CHARACTERISTICS OF ELECTRICAL CONNECTIONS TO THE EARTH [Tests on Small Samples of Soil].—Eaton. (*See* 424.)

VALVES AND THERMIONICS

480. DEFLECTED ELECTRON BEAMS [Continuation of Correspondence referred to in 57 of January : Reply to Gabor].—W. E. Benham. (*Wireless Engineer*, Dec. 1944, Vol. 21, No. 255, p. 584.)

481. MATHEMATICAL ANALYSIS OF RANDOM NOISE.—Rice. (*See* 440.)

482. NEW TUBES ["Button Base" Miniature Valves, Types 6AK6, 6AQ6, & 6AL5].—R. C. A. (*QST*, Aug. 1944, Vol. 28, No. 8, p. 32.)

483. THE 14Q7 AS A 12SA7 SUBSTITUTE [better than 12K7 or 14A7/12B7].—A. E. Hohman. (*QST*, Aug. 1944, Vol. 28, No. 8, p. 55.) With a supplementary note on the same page.

DIRECTIONAL WIRELESS

484. DIRECTION-FINDING SYSTEM ON THE ADCOCK PRINCIPLE [System where Individual Aerials act as Separate Heterodyne-Type Receivers (with Common Oscillator) and transmit Their I.F. Signals by Wireless to a Central Goniometer : Defect (Errors due to Independent I.F. Phase Rotations) eliminated by Choice of Heterodyning Frequency Very Close to Signal Frequency].—(*T.F.T.*, March 1944, Vol. 33, No. 3, p. 55.) D.R.P.740 589, applied for 6/4/38 : no name mentioned. An extension to D.R.P.718 517.

485. ELECTRONICS GUIDES 'PLANES [Blind Landing Indications by Single Pair of Crossed Pointers & Two Signal Lamps].—Westing-

house Company & Washington Institute of Technology. (*Scient. American*, Sept. 1944, Vol. 171, No. 3, p. 108.)

ACOUSTICS AND AUDIO-FREQUENCIES

486. Notes on Electro-Mechanical Equivalence.—Jefferson. (*See* 623.)

487. On the Motion of an Elastic Diaphragm coupled to an Acoustical System.—P. G. Bordoni. (*La Ricerca Scient.*, Dec. 1942, Vol. 13, No. 12, pp. 820–827.)

In many technical applications, such as the design of electrostatic microphones, the problem arises of rendering practically independent of frequency the mean amplitude of motion of an elastic diaphragm acted on uniformly over its whole surface by a pressure which varies sinusoidally with time. For this purpose the diaphragm is coupled to an acoustical system such that its impedance, adding itself to that of the diaphragm, alters the mechanical characteristics of the latter in the desired way. The amplitude of the forced vibration of the diaphragm is determined by calculation or experiment, and the parameters of the added acoustical system are varied until the mean amplitude is as independent of frequency as is possible.

In the present paper the writer starts from the equation $\mu \,.\, \partial^2\eta/\partial t^2 = T\nabla^2\eta + Pe^{j\omega t}$ (∇^2 = Laplace operator) for the motion of an elastic diaphragm excited by a sinusoidal pressure acting uniformly over its whole surface, and obtains an analytical expression for the impedance of the acoustical system, when coupled to the diaphragm, will give it the required independence of frequency. The approximate satisfaction of the calculated conditions by practical arrangements such as a disc (or better a ring), fixed at a definite distance from the diaphragm, is discussed; a subsequent paper will report on investigations on other acoustical systems giving better approximation to the conditions of eqns. 10 and 13.

488. On the Vibrations of a Clamped Plate under Tension [Treatment by Variational Method].—A. Weinstein & W. Z. Chien. (*Quart. Applied Math.* [Brown University], April 1943, Vol. 1, No. 1, pp. 61–68.)

Bickley (for condenser-microphone design) "was able to give the frequencies only for a small range of the tension" (1933 Abstracts, p. 333).

489. The Intrinsic Theory of Thin Shells and Plates: Part I—General Theory: Part II—Application to Thin Plates.—W. Z. Chien. (*Quart. Applied Math.* [Brown University], Jan. 1944, Vol. 1, No. 4, pp. 297–327: April 1944, Vol. 2, No. 1, pp. 43–59.)

"The various approximations used in the theory of thin shells and plates are confusing. If one attempts to give a complete picture of the theory, one must be able to introduce a systematic method of approximation, which not only clears away the confusion of various approximations but also leads to a complete classification of all thin shell and plate problems . . ." *See* also 488, above.

490. Stability of Columns and Strings under Periodically Varying Forces [including a Discussion of the Mathieu Equation with a Viscous Damping Term added].—S. Lubkin & J. J. Stoker. (*Quart. Applied Math.* [Brown University], Oct. 1943, Vol. 1, No. 3, pp. 215–236.)

491. The Distortion of the Boussinesq Field due to a Circular Hole, *and* The Thermal-Stress and Body-Force Problems of the Infinite Orthotropic Solid.—A. Barjansky: G. F. Carrier. (*Quart. Applied Math.* [Brown University], April 1944, Vol. 2, No. 1, pp. 16–30: pp. 31–36.) The first paper comes from the Brush Development Company.

492. Improving Headphone Quality: Simple Correction Circuits for Use with Conventional Diaphragm-Type Earpieces [Unexpectedly Large Range of Usual Type of Headphone (50 c/s to at least 15 kc/s): Various Resonances: Failure of Rubber Damping & of Shunt Acceptor Circuit: a Satisfactory Bass & Treble Boost Circuit: Need for a Matching Transformer: etc.].—S. W. Amos. (*Wireless World*, Nov. 1944, Vol. 50, No. 11, pp. 332–333.)

493. Smoothing the Performance of the Peak-Limiting Amplifier [for Recording: 3426 of 1943].—R. Lewis. (*QST*, Aug. 1944, Vol. 28, No. 8, p. 55.)

494. American Recordings [Agreement with Hartley's Views (3895 of 1944): a Matter of "Balance": Additions to Hartley's List of Good Recordings].—P. W. Granet: Hartley. (*Wireless World*, Nov. 1944, Vol. 50, No. 11, p. 350.)

495. Synthetic Music [Protest against Hartley's Arithmetical "Proof" of the Impossibility of producing Music by This Means (3898 of 1944): Defence of Stevenson's Article].—C. C. Buckle: Hartley. (*Wireless World*, Nov. 1944, Vol. 50, No. 11, pp. 349–350.)

496. Synthetic Sapphires [and Their Properties: Development of the Industry, particularly in Great Britain].—K. W. Brown & others. (*G.E.C. Journal*, Aug. 1944, Vol. 13, No. 2, pp. 53–59.)

497. Some "Corrective Comments" on the Paper "Acoustic Filtration and Hearing Aids" [83 of January].—M. B. A. Schier: Grossman & Molloy. (*Journ. Acous. Soc. Am.*, Oct. 1944, Vol. 16, No. 2, p. 126.)

498. A Clinical Comparison of Air- and Bone-Conduction Hearing Aids in Cases of Conductive Impairment of Hearing.—S. R. Silverman. (*Journ. Acous. Soc. Am.*, Oct. 1944, Vol. 16, No. 2, pp. 108–112.)

499. Researches on "Willis's Paracusia" [an Effect of Inverted Masking, found in Otosclerotic Patients: Apparatus & Results].—F. Lasagna & M. Nuovo. (*La Ricerca Scient.*, Nov. 1942, Vol. 13, No. 11, pp. 628–636.)

500. Fundamental Criteria for the Construction of an Acoustically and Electrically Screened Room for Physiological

AND PSYCHOLOGICAL RESEARCH, AND THE RESULTS OBTAINED.—A. Gemelli. (*La Ricerca Scient.*, Nov. 1942, Vol. 13, No. 11, pp. 619–627.)

501. ACOUSTICS OF SMALL ROOMS: FACTORS AFFECTING QUALITY OF REPRODUCTION.—J. Moir. (*Wireless World*, Nov. 1944, Vol. 50, No. 11, pp. 322–327.)

Leading to the conclusions that (i) sound quality in small rooms is determined by important factors additional to those responsible in large rooms; (ii) accurate "reproduction" of low-frequency notes appears impossible in small rooms; and (iii) sound quality in a small room may be "good," but never in the same sense as in a large room. Most of the writer's work was carried out in a room about 16′ 9″ × 11′ 6″ × 8′ 6″ high.

502. NEW RESEARCHES ON THE ACOUSTICAL CHARACTERISTICS OF THE PIANOFORTE.—A. Manfredi. (*La Ricerca Scient.*, Dec. 1942, Vol. 13, No. 12, pp. 804–819.)

503. CROSSTALK COUPLINGS IN TRANSPOSED COMMUNICATION CABLES: I—THE DISTRIBUTION OF THE COUPLING VALUES IN CROSSED CABLES OF GREAT LENGTH: II—THE DUAL-TRANSPOSITION METHOD FOR DECREASING THE CROSSTALK IN COMMUNICATION CABLES. —H. von Schelling: A. Koch. (*E.N.T.*, Nov./Dec. 1943, Vol. 20, No. 11/12, pp. 251–259: pp. 259–263.)

504. THE RAYLEIGH DISC AS A LABORATORY INSTRUMENT.—H. H. Roseberry & W. C. Smith. (*Journ. Acous. Soc. Am.*, Oct. 1944, Vol. 16, No. 2, pp. 123–125.)

505. A NEW METHOD FOR THE MEASUREMENT OF ACOUSTIC IMPEDANCES, *and* ON THE RADIATION OF ENERGY FROM AN ACOUSTIC RESISTANCE.—V. Thorsen. (*T.F.T.*, March 1944, Vol. 33, No. 3, pp. 61–62: summaries of two Copenhagen brochures.)

"Starting from a telephone receiver acting as an acoustic converter and joined to a tubular conductor of variable length, the energy radiated from the tube is measured and calculated as a function of the impedance of the tube and the terminating surface. In extension of the measuring possibilities with the Schuster bridge, the measurement of the acoustic resistance of raw materials or of plates with holes is undertaken. The method also enables data to be obtained for the design of an artificial ear.

"The second work gives the theoretical foundations of the method employed. From the acoustic analogue of the telegraphy equation in electrotechnics, the radiations from a tubular conductor having frictional losses are calculated, a convenient method being developed for dealing with the absorption and phase-jumps even in cases where a loss-resistance is present. Hitherto this was not possible for tubes with frictional losses."

506. A DIRECT-READING AUDIO-FREQUENCY METER [Portable & Self-Contained, on Condenser-Discharge-Current Principle, using the Seeley, Kimball, & Barco Circuit for Square-Wave Production (2329 of 1942): Range 0–30 000 c/s, accurate within 2% of Full-Scale Reading on All Six Ranges: about 1 Volt required for Operation, Indication is Independent of Input Voltage up to at least 300 Volts].—S. A. Lott. (*A.W.A. Tech. Review*, Aug. 1944, Vol. 6, No. 5, pp. 259–266.)

507. "WILLANS OSCILLATOR CIRCUIT": A CORRECTION.—E. A. Hanney. (*Wireless World*, Nov. 1944, Vol. 50, No. 11, p. 351.) *See* 3826 of 1944.

508. PRACTICAL APPLICATIONS OF SIMPLE MATHEMATICS: PART IV—DESIGNING A TWO-STAGE AUDIO AMPLIFIER.—E. M. Noll. (*QST*, Aug. 1944, Vol. 28, No. 8, pp. 50–54.)

509. A SOUND-OPERATED RELAY CONTROL: A CIRCUIT FOR REMOTE CONTROL OF BROADCAST RECEIVERS AND OTHER DEVICES [operated by a Handclap or Whistle, etc.]. —Conn. (*See* 467.)

510. SUPERSONIC INSPECTION METHODS [for Rapid Detection of Cracks, Differences in Hardness, Changes in Dimensions, & Variations in Composition: Three Methods, all involving Electronic Circuits].—B. A. Andrews. (*Electronics*, May 1944, Vol. 17, No. 5, pp. 122–124.) The three methods depend on the measurement of vibration frequencies, duration of sound, and absorption (or reflection) of supersonic waves.

511. A NEW METHOD FOR DETERMINING THE ELASTIC CONSTANTS OF CRYSTALS [using Supersonic Waves].—S. Bhagavantam & J. Bhimasenachar. (*Current Science* [Bangalore], Sept. 1944, Vol. 13, No. 9, pp. 229.) *See* also 99 of January.

512. YOUNG'S MODULUS OF ELASTICITY OF FIBRES AND FILMS BY SOUND-VELOCITY MEASUREMENTS.—J. W. Ballou & S. Silverman. (*Journ. Acous. Soc. Am.*, Oct. 1944, Vol. 16, No. 2, pp. 113–119.) *See* also 3904 of 1944.

513. THE VELOCITY OF SOUND IN VAPOURS.—K. Matta & M. Mokhtar. (*Journ. Acous. Soc. Am.*, Oct. 1944, Vol. 16, No. 2, pp. 120–122.)

514. OPTICAL EFFECT OF BLAST IN THE ATMOSPHERE [Correspondence: the Velocity of Shock Waves].—F. Postlethwaite & others. (*Engineering*, 29th Sept. & 13th Oct. 1944, Vol. 158, Nos. 4107 & 4109, pp. 254 & 294: contd. from previous issues.)

PHOTOTELEGRAPHY AND TELEVISION

515. ELECTRONIC INSTRUMENTS MAY BE MORE COMPACT [Television Sets, Electron Microscopes, etc., may use Tube bent at Right Angles, with "Target" at Bend at 45°].—K. Kohl. (*Sci. News Letter*, 2nd Sept. 1944, Vol. 46, No. 10, p. 153.) Patent vested in Alien Property Custodian.

516. PRACTICAL APPLICATIONS OF SIMPLE MATHEMATICS: PART V—VIDEO-AMPLIFIER DESIGN. —E. M. Noll. (*QST*, Sept. 1944, Vol. 28, No. 9, pp. 65–69.)

MEASUREMENTS AND STANDARDS

517. Wide-Band Amplifiers for Measuring Purposes, for Very Large Frequency Ranges.—Wunderlich. (*See* 441.)

518. Linearity of D.C. Vacuum-Tube Voltmeters [with Balanced Double-Triode Circuit].—Seville Chapman. (*Phys. Review*, 1st/15th Sept. 1944, Vol. 66, No. 5/6, pp. 159–160 : summary only.)

"The meter is usually connected between the plates of the two tubes. If, however, the load resistors are inserted in the cathode circuits, rather than in the plate circuits, and the meter is connected between the two cathodes, the plates being connected directly to the power supply, it is shown that without loss of sensitivity the departure from linearity . . . is reduced by a factor of from 2 to 4 in practical cases. Thus an increase in sensitivity by a similar factor can be obtained, or a less sensitive meter may be used for a performance equivalent to that of the usual circuit . . ."

519. A Portable Multimeter : a Combination Instrument for servicing WERS Equipment [combining Functions of Voltmeter, Milliammeter, Ohmmeter, Field-Intensity Meter, Frequency Meter, 'Phone Monitor, & Neutralising Indicator].—F. A. Long. (*QST*, Aug. 1944, Vol. 28, No. 8, pp. 18–22 and 59.)

520. Apparatus for Photographic Recording in the Measurement of Gravity by the Pendulum Method.—M. Chella & L. Solaini. (*La Ricerca Scient.*, Nov. 1942, Vol. 13, No. 11, pp. 683–697.)

521. Influence of Ultra-Violet Radiations on the Etching of Quartz [for Plate cut Normal to Optic Axis, Dissolution of Quartz in the Corrosive Acid is Far Greater in the Irradiated Portion : etc.].—Choong Shin-Piaw. (*Nature*, 21st Oct. 1944, Vol. 154, No. 3912, pp. 516–517.)

The investigations mentioned in 123 of January. The writer concludes : "Should this equality [a relation pointed out by Eck & Menabrea (ref. "2") regarding the angle formed by the three faces of a pyramid of corrosion with the plane normal to the optic axis] be not due to a fortuitous coincidence, the flattening and the change of orientation of the elementary pyramids might be regarded as evidence of some modification of the crystalline structure by the action of the u.v. radiations."

522. The Mounting and Fabrication of Plated Quartz Crystal Units, *and* Effects of Manufacturing Deviations on Crystal Units for Filters.—R. M. C. Greenidge : A. R. D'heedene. (*Bell S. Tech. Journ.*, July 1944, Vol. 23, No. 3, pp. 234–259 : pp. 260–281.)

Chapters 13 & 14 of the series dealt with in 3221/4 of 1944 and back references. Chapters 9–12 will be included in a forthcoming volume but are omitted from the *Journal*.

(i) Introduction : pressure-type units : wire-supported units (silver-spotting technique : silver plating : division of coating : attachment of wire supporting leads : types of wire attachments : mounting the crystal plate : housing of units : stabilisation : cleaning). (ii) Effects of deviations that occur in manufacture of plates : during fabrication of wire-supported units (including effects due to wire resonance, silver-spotting, etc.) : need for cleanliness and low relative humidity : effects of current level (*not* identical with those obtained with a change in ambient temperature).

523. Free Vibrations of Anisotropic Bodies [Approximate Solutions derived by Perturbation Method : Application to Calculation of Extensional Modes of Thin Crystal Plates : Calculated Frequencies & Deformation Patterns compared with Observations].—H. Ekstein. (*Phys. Review*, 1st/15th Sept. 1944, Vol. 66, No. 5/6, pp. 108–118.)

All comparisons with experiment for the longitudinal as well as the shear modes were made in cases where the parameters γ_{16} and γ_{26} vanish. Where these parameters are not negligibly small, the longitudinal and shear modes would be coupled and could not be treated separately as is done here.

524. A New Method for Determining the Elastic Constants of Crystals [using Supersonic Waves].—S. Bhagavantam & J. Bhimasenachar. (*Current Science* [Bangalore], Sept. 1944, Vol. 13, No. 9, pp. 229.) *See* also 99 of January.

525. The Intrinsic Theory of Thin Shells and Plates : Part I—General Theory : Part II—Application to Thin Plates.—Chien. (*See* 489.)

526. Papers on Elasticity Problems.—Barjansky : Carrier. (*See* 491.)

527. Correction to "Direct Reading of the Frequency of Resonant Circuits" [1647 of 1944].—W. H. F. Griffiths. (*Wireless Engineer*, Dec. 1944, Vol. 21, No. 255, p. 584.)

"The error is not very serious, because I have arrived at the correct answer in expression (21) which follows, and therefore none of the conclusions which follow is affected."

528. Automatic Calibrator for Frequency Meters [in particular, a Two-Band Army Meter required to Maintain an Accuracy within about 0.01% in the Field].—D. Sunstein & J. Tellier. (*Electronics*, May 1944, Vol. 17, No. 5, pp. 98–107 and 342..349.)

"A 126-tube electronic calibrator, combined with adding machines, records on paper tape the calibration data at 327 points for an Army SCR-211 two-band frequency meter, interpolates between these points, and automatically prints in the individual calibration book a five-digit dial number for 3252 frequency values." From the Philco Corporation.

529. "Prüffeldmesstechnik . . ." [Test-Room Measuring Technique : a Design for Measuring Installations for the Radio Industry : Book Review].—O. Limann. (*T.F.T.*, March 1944, Vol. 33, No. 3, pp. 58–59.) Based on ten years' experience in industry.

530. The Construction of Apparatus for Observation and Measurement.—P. Chevenard. (*Génie Civil*, 1st Aug. 1943, Vol. 120, No. 15, p. 177 : summary only.)

Guiding lines derived from the author's experience: he has been responsible for about forty instruments of precision, nearly all of them in current use in industry.

531. "ENGINEERING PRECISION MEASUREMENTS" [Book Notice].—A. W. Judge. (*Journ. of Scient. Instr.*, Nov. 1944, Vol. 21, No. 11, p. 203.)

532. PROPERTIES OF RADIO COMPONENTS: INTERPRETING "THE LABEL ON THE BOTTLE" [with Special Reference to the "Services' Radio Components Book" and the Work of the Inter-Service (Communications) Components Technical Committee: the Great Importance of Such Documents in Post-War Design for Export: etc.].—T. Roddam. (*Wireless World*, Nov. 1944, Vol. 50, No. 11, pp. 343–345.)

533. ELECTRONIC CIRCUIT DESIGN [the Three Steps—Conception, Working Model, Final Engineering Design: All affected by Normal Tolerances of Parts].—S. B. Ingram. (*Electronics*, May 1944, Vol. 17, No. 5, pp. 92–93.)

534. PROGRESS IN THE CONSTRUCTION OF SENSITIVE GALVANOMETERS [Survey].—G. Fouretier. (*Génie Civil*, 1st Oct. 1943, Vol. 120, No. 19, p. 226: summary only.)

SUBSIDIARY APPARATUS AND MATERIALS

535. INSTRUMENT PACKING CASES.—Postlethwaite. (*Engineering*, 27th Oct. 1944, Vol. 158, No. 4111, pp. 321–323.)

"Only a small degree of protection is afforded by such instructions as 'Instruments—Handle with Care,' 'Fragile,' 'This Side Up with Care,' etc. The ideal packing case should give the same degree of protection irrespective of the side it rests on . . ." The final design of a packing case for cathode-ray tubes "was so successful that it was decided to examine the possibility of arranging instrument-packing-case suspensions on somewhat similar lines. At the same time, tests were put into operation to investigate existing methods of packing instruments." The investigations are described and discussed.

536. CATHODE-RAY TUBES: RAPID METHOD OF ADJUSTING THE DISTANCE [which must be Accurate to a Hundredth of a Millimetre] BETWEEN THE APERTURE OF THE MODULATING STOP AND THE ADJACENT FACE OF THE CATHODE.—(*T.F.T.*, April 1944, Vol. 33, No. 4, pp. 82–83, Fig. 11.) D.R.P.740 384, applied for 2/9/39. With ordinary mass-production methods such an adjustment would take a long time.

537. ELECTRONIC INSTRUMENTS MAY BE MORE COMPACT [Cathode-Ray Tube bent at Right Angles, with "Target" at Bend at 45°].—Kohl. (*See* 515.)

538. THE ELECTROFLUOROSCOPE AND ITS APPLICATIONS [New Instrument, replacing Cathode-Ray Oscillograph for Certain Purposes (primarily in Biological Research): with Fluorescent Screen in Steady Continuous Motion which can be Stopped when desired so that a Particular Part of Trace can be Examined, Photographed, etc: No Scanning].—Minot. (*Génie Civil*, 15th Dec. 1942, Vol. 119, No. 27, pp. 334–335: summary only.)

539. MICROANALYSIS BY MEANS OF ELECTRONS [Theory & Design of the Electron Microanalyser (1292 of 1944), and Discussion of Theoretical Implications of Results obtained].—Hillier & Baker. (*Journ. Applied Phys.*, Sept. 1944, Vol. 15, No. 9, pp. 663–675.) *Cf.* 540, below.

540. ON ELECTRON MICROSPECTROSCOPY.—Marton. (*Phys. Review*, 1st/15th Sept. 1944, Vol. 66, No. 5/6, p. 159: summary only.)

"The energy losses of fast electrons corresponding to K levels of light elements, and observed first by G. Ruthemann, were used by J. Hillier in an instrument designed for the investigation of the composition of small specimens [1292 of 1944, where Ruthemann's work is also referred to, and 539, above]. His instrument, called an 'electron microanalyser,' consists of an inverted electron microscope producing a small probe on the surface of the specimen, with analysis of the transmitted beam and image formation by the shadow method.

"Our investigations show that the energy losses can be observed in a transmission type of electron microscope. For such a purpose an attachment is built on to the Stanford electron microscope replacing the transparent fluorescent screen used for end-on viewing of the image . . ." The attachment is described: it achieves the simultaneous observation of the highly magnified image and of its velocity spectrum. Some of the results obtained are discussed in the full paper.

541. STUDIES WITH THE [R.C.A.] ELECTRON MICROSCOPE DIFFRACTION ADAPTER [2202 of 1943: Results obtained: Effect of Weak Magnetic Focusing on Accuracy of Diffraction Data: Method of Measuring the Accelerating Voltage of Electrons from Diffraction-Pattern Data: Effects of Aging & Beam-Exposure: etc.].—Picard. (*Journ. Applied Phys.*, Sept. 1944, Vol. 15, No. 9, pp. 678–684.)

542. THE ELECTRON MICROSCOPE, GIVING A MAGNIFICATION OF 45 000 [Siemens Supermicroscope, Ruska–von Borries Type: Illustrated Article].—Calfas. (*Génie Civil*, 1st Dec. 1942, Vol. 119, No. 26, pp. 313–315.)

543. DEFLECTED ELECTRON BEAMS [Continuation of Correspondence referred to in 145 of January: Reply to Gabor].—Benham. (*Wireless Engineer*, Dec. 1944, Vol. 21, No. 255, p. 584.)

544. RIGOROUS CALCULATION OF AN ELECTROSTATIC IMMERSION LENS [General Solution of Paraxial-Ray Differential Equation, combined with Fact that Newton's Image Equations are Satisfied, yields Exact Expressions for the Optical Quantities: etc.]. Hutter. (*Phys. Review*, 1st/15th Sept. 1944, Vol. 66, No. 5/6, p. 161: summary only.) For previous work *see* 1296/7 of 1944.

545. On Herzberger's Direct Method in Geometrical Optics.—Synge: Herzberger. (*Quart. Applied Math.* [Brown University], Oct. 1943, Vol. 1, No. 3, pp. 268–272.)

As developed in Herzberger's papers "Direct Methods in Geometrical Optics" and "A Direct Image-Error Theory," the second of which appeared in the April issue, No. 1, pp. 69–77. "If we combine Herzberger's 'direct method' with Hamilton's character function we obtain a very powerful technique . . ."

546. The Effect of Heat Treatment on the *K*-Absorption Edge of Zinc in Zinc Sulphide.—Bose & Sen Gupta. (*Sci. & Culture* [Calcutta], Sept. 1944, Vol. 10, No. 3, pp. 135–136.)

"Seitz interprets the blue luminescence in terms of the interstitial zinc atoms, but this interpretation has been criticised by Randall and others in several respects, mainly because the existence of these atoms has not been demonstrated experimentally." The results of the present X-ray tests "may be taken at least qualitatively as an indication of the existence of some free zinc atoms in the lattice . . ."

547. Increase of Phosphorescence during Excitation.—Antonov-Romanovsky. (*Comptes Rendus (Doklady) de l'Acad. des Sci. de l'URSS*, 20th June 1943, Vol. 39, No. 8, pp. 299–302: in English.)

"The exciting light does not only ionise the centres of luminescence, but not infrequently brings about a more rapid decay of the luminous power of the phosphor. This leads to results that look rather paradoxical at first sight; it is the analysis of these results that we are concerned with in the present article."

548. Fluorescent Screens of High Resolving Power [*e.g.* for Ultra-Violet Spectroscopy: the Use of Certain Plastics dyed on the Surface with a Fluorescent Substance].—Zelinsky. (*Comptes Rendus (Doklady) de l'Acad. des Sci. de l'URSS*, 30th Aug. 1943, Vol. 40, No. 6, pp. 220–222: in English.)

549. The Cyclotron and Betatron [Paper based on Chairman's Address to Electronics Group, Institute of Physics].—Cockcroft. (*Journ. of Scient. Instr.*, Nov. 1944, Vol. 21, No. 11, pp. 189–193.) Including at the end a short discussion of the steps necessary to reach cosmic-ray energies (*cf.* 3961 of 1944 and 550, below).

550. The Spirotron [for stopping Very-High-Speed Particles].—Dodd. (*See* 420.)

551. The Apparent Breakdown of Meek's Streamer Criterion in Divergent Gaps due to the Failure of Townsend's Ionisation Function.—Fisher & Weissler. (*Phys. Review*, 1st/15th Sept. 1944, Vol. 66, No. 5/6, pp. 95–102.)

552. Glass-to-Metal Soldering made possible by Metallising.—American Meter. (*Scient. American*, Sept. 1944, Vol. 171, No. 3, p. 132.)

553. A High-Voltage D.C. Regulator entirely A.C. Operated [developed from Degenerative Type (Hunt & Hickman, 1691 of 1939): Use of *RC* Combination which for Short-Duration Voltage-Fluctuations has Effect of Increasing the Fraction of High Voltage that is Compared with the Reference Voltage].—McGee. (*Phys. Review*, 1st/15th Sept. 1944, Vol. 66, No. 5/6, pp. 160–161: summary only.)

554. The "Stabilistor", an Improved A.C. Voltage Stabiliser.—Walker. (*Wireless World*, Nov. 1944, Vol. 50, No. 11, pp. 339–341.)

From the Westinghouse Brake & Signal Company's Research Department. "Although it operates on the principle of magnetic saturation [like previous designs whose defects are discussed] it will provide a substantially sinusoidal output voltage over a wide range of load; moreover, the output voltage is held within fine limits in spite of simultaneous variations in both input voltage and magnitude of load . . ."

555. Electronic Power Converters: Their History and Development [and the Suppression of Electronic Faults (Arc-Back & "Shoot-Through"—Loss of Grid Control): the "Single-Conversion Frequency Changer" (used with the Thyratron Motor): the D.C. Transformer (awaiting a Demand): etc.].—Alexanderson & Phillipi. (*Gen. Elec. Review*, Sept. 1944, Vol. 47, No. 9, pp. 41–45: *Elec. Engineering*, Sept. 1944, Vol. 63, No. 9, Transactions pp. 654–657).

556. Power-Supply Design: the Principal Factors involved in the Reduction of Ripple.—Hamilton. (*QST*, Aug. 1944, Vol. 28, No. 8, pp. 26–28.)

557. A Note on Electrolytic Interrupters [Report on Further Investigations on Wehnelt and Caldwell & Simon Types, and New Combinations: the Best Electrodes: Important Factors].—Lal. (*Sci. & Culture* [Calcutta], Sept. 1944, Vol. 10, No. 3, pp. 132–133.)

558. Investigations on Current-Supply Installations for Telegraphy [Conclusion of 3251 of 1944].—Schmidl. (*T.F.T.*, Dec. 1943, Vol. 32, No. 12, pp. 259–263.)

559. The Smallest High-Voltage Storage Battery ever produced Commercially [36-Volt Unit weighs 6 Ounces: "Vacuum-Pack" Principle for Instant Filling with Electrolyte].—Willard Storage Battery. (*QST*, Sept. 1944, Vol. 28, No. 9, p. 73.) For radiosonde transmitters, etc.

560. Wet Storage Batteries for Flashlights Perfected [outlasting 400 Dry Cells].—Goodrich Company. (*Sci. News Letter*, 9th Sept. 1944, Vol. 46, No. 11, p. 174.)

561. Aircraft Fuses Must Protect.—Lebens. (*Elec. Engineering*, Aug. 1944, Vol. 63, No. 8, Transactions pp. 581–585.)

562. HISTORICAL DEVELOPMENT OF ELECTRICAL CONNECTORS, *and* ELECTRICAL CONNECTIONS ON AIRCRAFT.—Neifing: Stebbins & Taylor. (*Elec. Engineering*, Aug. 1944, Vol. 63, No. 8, p. 312: p. 313: summaries only.)

563. SOLDERLESS TERMINALS [Advantages: Description & Method of Crimping: Corrosion Test Procedures: etc.].—Wells & Balsbaugh. (*Elec. Engineering*, Aug. 1944, Vol. 63, No. 8, p. 312: summary only.)

564. PROTECTIVE TREATMENTS FOR METALLIC SURFACES [Survey].—de Smet. (*La Machine moderne*, June 1943: summary in *Génie Civil*, 1st Oct. 1943, Vol. 120, No. 19, pp. 224–225.)

565. A "HAND-SCREENING" PROCESS FOR AMATEUR INSTRUMENT-PANEL LETTERING: A SIMPLIFIED HAM-BREW METHOD OF LABELLING CONTROLS, BASED ON THE COMMERCIAL SILK-SCREEN PROCESS. — Foot. (*QST*, Aug. 1944, Vol. 28, No. 8, pp. 38–39.) From the Hallicrafters Company.

566. SYNTHETIC SAPPHIRES [and Their Properties: Development of the Industry, particularly in Great Britain].—Brown & others. (*G.E.C. Journal*, Aug. 1944, Vol. 13, No. 2, pp. 53–59.)

567. SYNTHETIC BONDED MICA.—Barringer & Mathes. (*Gen. Elec. Review*, Oct. 1944, Vol. 47, No. 10, pp. 15–19.)

Introduction: era of shellac-bonded built-up mica: period of alkyd-resin bonding ("Glyptal Mica", "Super-Micanite"): use in radio and other applications: new 7000, Synthetic Resin bond: comparative tsts.

568. NEW SYNTHETIC FIBRE [for Insulation: "Fortisan"].—British Celanese. (*Electrician*, 17th Nov. 1944, Vol. 133, No. 3468, p. 454.)

569. THE ACTION OF EMULSIFYING AGENTS UPON THE STABILITY OF SYNTHETIC RESINS.—Vaskevich & Baklazhez. (*Comptes Rendus (Doklady) de l'Acad. des Sci. de l'URSS*, 30th June 1943, Vol. 39, No. 9, pp. 354–356: in English.)

570. NEW METHOD OF MOULDING THERMO-PLASTICS [primarily Polythene, but with Other Possibilities: Extrusion Method].—Metropolitan-Vickers. (*Engineer*, 29th Sept. 1944, Vol. 178, No. 4629, pp. 249–250: *Engineering*, 13th Oct. 1944, Vol. 158, No. 4109, pp. 287–288.)

571. NEW TYPES OF HIGH-TEMPERATURE THERMOPLASTICS, "STYRAMIC HT" AND "CEREX".—Monsanto Chemical. (*QST*, Aug. 1944, Vol. 28, No. 8, p. 59: paragraph only.) *See* also 3984 of 1944.

572. PLASTICS IN AIRCRAFT ELECTRICITY [and Some of Their Limitations: Lack of Several Significant Data in Usual Tables of Plastics: etc.].—Cooper. (*Elec. Engineering*, Aug. 1944, Vol. 63, No. 8, p. 313: summary only.)

573. THE TESTING OF MOULDED PLASTIC OBJECTS BY X-RAYS.—Guinier. (*Génie Civil*, 1st Sept. 1943, Vol. 120, No. 17, p. 204: summary only.)

If the thickness traversed by the rays is 10 mm, density differences of 1% are easily detected.

574. THE CHEMISTRY OF PLASTICS.—Chirnside. (*G.E.C. Journal*, Aug. 1944, Vol. 13, No. 2, pp. 74–89.)

575. A BALL IMPACT TESTER FOR PLASTICS.—Stock. (*A.S.T.M. Bulletin*, Oct. 1944, No. 130, pp. 21–26.)

576. THE VARIATION WITH TEMPERATURE OF THE DYNAMIC PROPERTIES OF RUBBER AND SYNTHETIC RUBBER-LIKE MATERIALS.—Fletcher & Schofield. (*Journ. of Scient. Instr.*, Nov. 1944, Vol. 21, No. 11, pp. 193–198.)

577. PLASTIC MATERIALS FROM VEGETABLE PRODUCTS [Padua University Researches].—Meneghini & Sorgato. (*La Ricerca Scient.*, Dec. 1942, Vol. 13, No. 12, pp. 756–763.) With literature and patent references.

578. RADIO-FREQUENCY DIELECTRIC PROPERTIES OF A CELLULOSIC SYSTEM AT LOW MOISTURE CONTENTS.—Dunlap & Makower. (*See* 678.)

579. CERAMIC WIRE INSULATION ["Ceroc 200", maintaining Desirable Electrical Characteristics at Continuous Operating Temperature of 200°C].—Sprague Electric. (*Gen. Elec. Review*, Oct. 1944, Vol. 47, No. 10, p. 70.)

580. SOLID SOLUTIONS OF CALCIUM AND STRONTIUM ORTHOSILICATES [used increasingly in Ceramic Materials, etc.].—Toropov & Konovalov. (*Comptes Rendus (Doklady) de l'Acad. des Sci. de l'URSS*, 10th Aug. 1943, Vol. 40, No. 4, pp. 155–157: in English.)

581. ON THE STRUCTURE OF COMPLEX GLASSES [Boric-Oxide–Silica & Soda–Silica Glasses].—Poray-Koshitz. (*Comptes Rendus (Doklady) de l'Acad. des Sci. de l'URSS*, 30th Sept. 1943, Vol. 40, No. 9, pp. 346–349: in English.)

582. A NEW H. F. CAPACITOR [with Low Impedance over a Wide Frequency Range].—Allison & Beverly. (*See* 450.)

583. DUNDAS "DRYAIR" ELEMENTS [Dessicating Elements (containing Colloidal Silica) with Colour Indicator: Many Applications, including to Aircraft Instruments, Standard Air-Dielectric Condensers, etc.].—Dundas, Ltd. (*Wireless World*, Nov. 1944, Vol. 50, No. 11, p. 333: *Wireless Engineer*, Dec. 1944, Vol. 21, No. 255, p. 585.)

584. "PRINCIPLES OF POWDER METALLURGY" [Book Review].—Skaupy. (*Gen. Elec. Review*, Oct. 1944, Vol. 47, No. 10, p. 74.) A review of a German book by this author was referred to in 1347 of 1944: the book now reviewed seems to be a translation of this.

585. A Note on the Inductance Variation [with Core Position] in R.F. Iron-Cored Coils.—Bushby. (*See* 449.)

STATIONS, DESIGN AND OPERATION

586. Automatic Relaying [Editorial prompted by News (Aug. issue, No. 8, p. 58) of Granting of Concession to A.T. & T. to erect Chain of Automatic Relay Stations between Boston & New York, on Wavelengths between 2.5 & 15 cm: Sketch of Possible Automatic-Relay Scheme for Amateurs for the Future].—(*QST*, Sept. 1944, Vol. 28, No. 9, pp. 7–8.)

587. Police Satellite System [F.M. Signals from Cars in Remote Areas automatically Relayed to Central Point].—Naschke. (*See* 473.)

588. Radar and Micro-Wave Communication for Trains.—Chicago, Rock Island, & Pacific Railway. (*Scient. American*, Sept. 1944, Vol. 171, No. 3, p. 108: note on a programme of study and experiment.)

589. Carrier-Frequency Transmission System for Communication between Fixed and Moving Stations or between Moving Stations [along Trolley-Wires, etc: Trouble with Standing Waves (due to the Complexities of the Wire System, and causing Violent Fluctuations of Signal Strength: *cf.* 234 of January) overcome by Simultaneous Use of Two or More Channels].—(*T.F.T.*, March 1944, Vol. 33, No. 3, p. 56.) D.R.P.740 337, applied for 22/9/39: no name mentioned.

590. Plans for Taxi-Cab Two-Way Radio Communication.—Cab Research Bureau & General Electric. (*Scient. American*, Sept. 1944, Vol. 171, No. 3, p. 108.)

591. A CAP [Coastal Air Patrol] Radio System: WERS in the Sheboygan County (Wis.) Flight as organised from the Ground up.—Capelle. (*QST*, Aug. 1944, Vol. 28, No. 8, pp. 29–32.)

592. Jap Radio Equipment: the Model 13 Command Set [7–11 Mc/s Transmitter–Receiver with C.W., M.C.W., & Speech: including General Observations, and Comparison with German & American Equipment].—Gordon. (*Electronics*, May 1944, Vol. 17, No. 5, pp. 126–129 and 339..341.)

593. World Radio Charter [Note on Hubert's Proposals for an "International Radio Charter"].—Hubert. (*Wireless World*, Nov. 1944, Vol. 50, No. 11, p. 327.) *See* also 3645 of 1944.

594. Monthly Commentary: A Place in the Ether ["Few Signs of Any Intense Official Activity in This Country"].—(*See* 642.)

595. Extending Wireless Applications [Vast Field Cannot be opened up without Change in Present P.O. Licensing Regulations: Need for Claims to be Well Staked before Next International Conference].—Hart. (*Wireless World*, Nov. 1944, Vol. 50, No. 11, p. 351.)

596. Effect of Telegraph Distortion on the Margins of Operation of Start-Stop Receivers [in Teletypewriter & Teletypesetter Systems].—Rea. (*Bell S. Tech. Journ.*, July 1944, Vol. 23, No. 3, pp. 207–233.)

597. Band-Width Expenditure and Reliability of Operation of Various Wireless Telegraphy Systems.—Kotowski. (*E.N.T.*, Nov./Dec. 1943, Vol. 20, No. 11/12, pp. 270–276.)

Hell's latest (seven-line) system requires 49 impulses per letter and leads to a performance of only 0.5 wpm per c/s: it is consequently bad as regards band-width expenditure, though it is particularly insensitive to disturbance. The telautograph system is credited with 0.6 wpm per c/s. The Hudec pulse system is good for overcoming short-wave troubles, but to guard against most echo effects the pulse must not be longer than 10^{-3} second and the delay time must be about 8 milliseconds, so that 8/9ths of the time is lost and the frequency-band utilisation is worse than that of the five-unit code by a factor of 9. Thus as regards reliability the Hudec system should be compared with a nine-unit system, which does not at present exist: it seems doubtful whether such a system would give better results. The Hudec system as it stands is given a performance of 0.6 wpm per c/s. Runge has suggested that it could be improved by using it with the Hughes alphabet, since the delay time would then appear only once for each letter.

Next on the list, with a performance of 0.9 wpm per c/s, comes a system using an impulse of different frequency for each of the 26 letters. The possibilities of phase-keying are discussed on p. 273, r-h column: in a sufficiently phase-rigid circuit a single impulse could be either of three things—absent, present, or present in counter-phase. But in short-wave working the rigidity of the path would be insufficient: it is known from experience with the pulse system that in transoceanic communication the attenuation difference frequently varies by as much as 1 neper in one second, occasionally in one-thirtieth of a second, and so phase reversals would be liable to occur.

The Hughes system is credited with 1.72 wpm per c/s, the "Springschreiber" (start-stop teletype) with 3.3 or, operated synchronously, with 4.8 wpm per c/s. This last value is also given to the Baudot system with 5 impulses per letter. The use of a specialised code such as Scharl's Alpha Code or the ABC Code raises the performance to 7 wpm per c/s.

GENERAL PHYSICAL ARTICLES

598. On the Representation of an Arbitrary Function by an Integral involving Legendre's Functions with a Complex Index [in Certain Problems of Potential Theory].—Fock. (*Comptes Rendus (Doklady) de l'Acad. des Sci. de l'URSS*, 10th June 1943, Vol. 39, No. 7, pp. 253–256: in English.) *See*, for example, 387, above.

599. Planck's Universal Constant of Action [Relation obtained between Planck's Two Constants (Unit Electric Charge & Universal "Quantum of Action" *h*), considered by Planck to be Independent].—Cook. (*Phys.

Review, 1st/15th Sept. 1944, Vol. 66, No. 5/6, p. 161: summary only.)

"The paper shows that *e*, the electric charge on an electron, is the real 'constant of action' and that *h* is a constant which acts as a factor to measure the energy developed in the radiation quantum developed by *e*. The ratio of *e* and *h* is determined as a constant *k*."

600. MASS–ENERGY RELATION [a Survey of Theory & Experiment].—Dushman. (*Gen. Elec. Review*, Oct. 1944, Vol. 47, No. 10, pp. 6–13.)

601. MOMENTUM AND ENERGY OF PHOTON AND ELECTRON IN THE ČERENKOV RADIATION.—Cox. (*Phys. Review*, 1st/15th Sept. 1944, Vol. 66, No. 5/6, pp. 106–107.)

602. A RELATIVISTIC THEORY OF TEMPERATURE RADIATION [" Special " Theory only, applicable to Bodies radiating at Constant Temperature: Field of Application, etc.].—Dingle. (*Phil. Mag.*, Aug. 1944, Vol. 35, No. 247, pp. 499–518.)

603. STATISTICAL MECHANICS AT EXTREMELY HIGH TEMPERATURES [equal to or above 10^9 Degrees].—Wataghin. (*Phys. Review*, 1st/15th Sept. 1944, Vol. 66, No. 5/6, pp. 149–154.)

"It is found that because of the behaviour of some high-energy particles, known experimentally from observations on cosmic rays and nuclei, some limitations arise to the laws of quantum statistics, in accordance with the idea of the existence of a supplementary indeterminacy for high-energy particles and a lower limit for measurable lengths . . ."

604. LONG DURATION OF THE BALMER SPECTRUM IN EXCITED HYDROGEN.—Rayleigh. (*Proc. Roy. Soc.*, Ser. A, 10th Aug. 1944, Vol. 183, No. 992, pp. 26–32 & Plate.)

"This is a thousand times greater than the period usually assigned from theoretical considerations . . . Experimental work which seems out of harmony with established fashions of thought does not easily find its way into books, and is apt to be soon forgotten. The writers of text-books and summaries of literature do not know how to deal with it, and find the easiest solution is not dealing with it at all . . ."

605. SOLUTIONS OF PROBLEMS RELATING TO MEDIA IN CONTACT, BY THE METHOD OF WAVE-TRAINS.—Green. (*Phil. Mag.*, Aug. 1944, Vol. 35, No. 247, pp. 519–531.)

In an earlier paper (ref. " 1 " [and *cf.* 1931 Abstracts, p. 632, top l.h column]), dealing with heat-conduction problems, the method was described, and illustrated by an application to concentric spherical media in contact. "The summations of effects represented by wave-trains obtained in this paper are the same as would be required for any two concentric spherical media in contact and for any effects transmitted through the media by wave-motion. They may also be applied to effects transmitted by plane waves. The summations of wave-train effects—which are essential to facilitate the general application of the wave-train method—require to be summarised and arranged for this purpose: and it is proposed to do so in the present paper. In the latter part of the present paper these tabulated results are applied to the solution of problems dealing with vibrations in composite media; this part being an extension of the work contained in a former paper (3247 of 1940 and back reference). Thereafter attention is drawn to the fact that the method of solution by wave-trains readily provides an equation for the determination of periods of vibration of composite media under a wide variety of boundary conditions." *See* also 2529/30 of 1936.

606. ON A NEW THEORY OF THE ELECTROMAGNETIC FIELD [Bopp's New Classical Theory (927 of 1941), exempt from Various Essential Difficulties inherent in Previous Variants of Classical Theory].—Nikolsky: Bopp. (*Comptes Rendus* (*Doklady*) *de l'Acad. des Sci. de l'URSS*, 20th Sept. 1943, Vol. 40, No. 8, pp. 309–312: in English.) *See* also Podolsky, 237 of 1943.

607. ON BIRKHOFF'S NEW THEORY OF GRAVITATION [Ref. " 2 " and 3010 of 1944: Critical Analysis of Weyl's Objections to the Theory: etc.].—Barajas, Birkhoff, Graef, & Vallarta. (*Phys. Review*, 1st/15th Sept. 1944, Vol. 66, No. 5/6, pp. 138–143.)

608. FLAT SPACE-TIME AND GRAVITATION.—Birkhoff. (*Proc. Nat. Acad. Sci.*, Oct. 1944, Vol. 30, No. 10, pp. 324–334.)

Cf. Weyl, 235 of January, and 607, above, "Thus curved space-time has come to be regarded by many as an auxiliary construct (Larmor) rather than as a physical reality. In my opinion, the failure of the early attempts by Nordström and others to develop a theory of gravitation in flat space-time is to be attributed to the fact that a fundamental theoretic requirement was overlooked, namely that the disturbance velocity in matter must be that of light . . ."

MISCELLANEOUS

609. ERRATA: ON THE PERTURBATION OF BOUNDARY CONDITIONS [4026 of 1944].—Feshbach. (*Phys. Review*, 1st/15th Sept. 1944, Vol. 66, No. 5/6, p. 157.)

610. ON THE REPRESENTATION OF AN ARBITRARY FUNCTION BY AN INTEGRAL INVOLVING LEGENDRE'S FUNCTIONS WITH A COMPLEX INDEX.—Fock. (*See* 598.)

611. NOTE ON CERTAIN INTEGRALS INVOLVING HERMITE'S POLYNOMIALS [and occurring frequently in Quantum-Mechanical Investigations].—Baber & Mirsky. (*Phil. Mag.*, Aug. 1944, Vol. 35, No. 247, pp. 532–537.) So far as the writers are aware, no method of calculating these integrals has hitherto been published.

612. PROPOSED SYMBOLS FOR THE MODIFIED COSINE AND EXPONENTIAL INTEGRALS [for Problems of Electromagnetic Radiation].—Schelkunoff. (*Quart. Applied Math.* [Brown University], April 1944, Vol. 2, No. 1, p. 90.)

Reasons are given for the use of the modified cosine integral $\mathrm{Cin}\, x = \int_0^x (1 - \cos t)/t\, dt$ instead of the standard cosine integral $\mathrm{Ci}\, x$. Further, as one is frequently interested in the analytic properties of impedance functions over the entire oscillation constant plane, the modified exponential integral Ein $z = \int_0^z \{(1 - e^{-w})/w\} dw$ is suggested and discussed.

613. Mechanical Integrator, Bush System, applicable to Ordinary Differential Equations [Principle of the Askania Company's Version, developed in Germany].—Sauer & Pösch. (*Zeitschr. V.D.I.*, 17th April 1943, Vol. 87: long summary in *Génie Civil*, 1st Sept. 1943, Vol. 120, No. 17, pp. 199–200.)

614. The Transformation of Partial Differential Equations.—Bateman. (*Quart. Applied Math.* [Brown University], Jan. 1944, Vol. 1, No. 4, pp. 281–296.)

Introduction: associated equations of the types of Monge and Legendre: the transformation of the Monge–Ampère equation: of the linear equation: of Legendre's equation: references.

615. "Intermediate Differential Equations" [Book Review].—Rainville. (*Gen. Elec. Review*, Sept. 1944, Vol. 47, No. 9, pp. 62–63.) "To fill a gap which has been recognised for some time . . ."

616. On a Generalisation of Bessel Functions.—Olevsky. (*Comptes Rendus* (*Doklady*) *de l'Acad. des Sci. de l'URSS*, 10th July 1943, Vol. 40, No. 1, pp. 5–10: in English.)

617. Relation between Operational Expressions of Two Arbitrary Functions and the Operational Representation of Their Product.—Grünberg. (*Comptes Rendus* (*Doklady*) *de l'Acad. des Sci. de l'URSS*, 10th Aug. 1943, Vol. 40, No. 4, pp. 141–143: in English.)

"In a discussion on non-linear problems that recently took place, A. A. Kharkevich expressed the idea that new ways for the application of the operational calculus to non-linear problems and to problems reducible to linear equations with variable coefficients [*cf.* Wylie, 3657 of 1944] might possibly be opened up by establishing a relation between operational expressions of two arbitrary functions and the operational representation of their product." Such a relation is given by the general theorem set out and proved in the present Note.

618. Some Present Non-Linear Problems of the Electrical and Aeronautical Industries.—Keller. (*See* 446.)

619. The Engineer Grapples with Non-Linear Problems.—von Karman. (*See* 447.)

620. On Mechanical Self-Excited Oscillations [Frequently Observed in Practice].—Minorsky. (*Proc. Nat. Acad. Sci.*, Oct. 1944, Vol. 30, No. 10, pp. 308–314.)

"It is seen that the principal features of the phenomenon in questions are consistently explained on the basis of non-linear mechanics. In fact, if one had to follow purely linear methods it would be impossible even to predict the existence of a phenomenon of this nature." *See* also 285 of 1943.

621. Torsional Vibration of Multi-Disc Systems [Asymptotic Method of calculating Lowest Frequencies, with Three Advantages: using Pipes's Matrix Method (3419 of 1942)].—Fisher. (*Journ. Applied Phys.*, Sept. 1944, Vol. 15, No. 9, pp. 676–677.) Primarily in connection with multi-cylinder "Diesel" engines.

622. Stability of Columns and Strings under Periodically Varying Forces [including a Discussion of the Mathieu Equation with a Viscous Damping Term added].—Lubkin & Stoker. (*Quart. Applied Math.* [Brown University], Oct. 1943, Vol. 1, No. 3, pp. 215–236.)

623. Notes on Electro-Mechanical Equivalence.—Jefferson. (*Wireless Engineer*, Dec. 1944, Vol. 21, No. 255, pp. 563–570.)

"In comparison [with electric filter design], the solution of problems in mechanical systems is very clumsy. Each problem must be treated as a fresh one and the basic equations for each element written down. From this assembly of Newton's laws and Hooke's law the required solution can be painfully extracted. The solution is cluttered up with unwanted information about conditions in intermediate meshes.

"It is well known that the methods evolved for electric circuit design can be used for mechanical circuit design . . . Many mechanical engineers, however, are reduced to computation from first principles, or to 'cut-and-try' methods, because they have found no sufficiently clear account of the operation of expressing mechanical systems in terms of electrical networks . . . It is the purpose of these notes to develop the bases of equivalent systems and to maintain through this development the complete duality which exists. This duality is obscured by many of the writers: it arises because there is no fundamental reason why the equivalent of force should be voltage rather than current, or the equivalent of velocity current rather than voltage . . ."

Apart from helping in the solution of mechanical problems, it is hoped that the paper will assist towards a rational approach to problems of mixed transducers, and "that the result, believed to be new, in Fig. 12 will be of use to those who find a need for constant-k band-pass filters or high-pass filters."

624. A Geometrical Interpretation of the Relaxation Method.—Synge: Southwell. (*Quart. Applied Math.* [Brown University], April 1944, Vol. 2, No. 1, pp. 87–89.)

625. Coefficients for Interpolation within a Square Grid in the Complex Plane.—Lowan & Salzer. (*Journ. of Math. & Phys.* [of M.I.T.], Aug. 1944, Vol. 23, No. 3, pp. 156–166.)

626. On the Growth of Homogeneous Random Processes with Independent Single-Type Increments.—Gnedenko. (*Comptes Rendus* (*Doklady*) *de l'Acad. des Sci. de l'URSS*, 30th July 1943, Vol. 40, No. 3, pp. 90–93: in English.) For a subsequent Note, "On the Iterated Logarithm Law for Homogeneous Random Processes with Independent Increments," *see* issue for 10th Sept. 1943, No. 7, pp. 255–256.

627. Solution of the Restricted Problem of the "Random Walk" [investigated by Rayleigh in connection with the Composition of Iso-periodic Vibrations of Equal Amplitude and of Phases distributed at Random: Simplification by Restriction to Two Fixed Directions].—Silberstein. (*Phil. Mag.*, Aug. 1944, Vol. 35, No. 247, pp. 538–543.)

628. Intensity Fluctuations in Telephone Traffic [Discrepancies between Practice & Theoretical Equations attributed (by Stochastic Treatment) to an Intensity Fluctuation].—Palm. (*T.F.T.*, March 1944, Vol. 33, No. 3, pp. 57–58: critical summary of work published in Special Number 44 of *Ericsson Technics*.)

629. Quality Control when Manufacturing to Specification: Statistics as an Aid to Production Efficiency.—Dudding & Jennett. (*G.E.C. Journal*, Aug. 1944, Vol. 13, No. 2, pp. 60–64.) A fuller treatment is contained in a book under the same title, published by the G.E.C.

630. New Mathematical Tables, 12th June, 1944 [MT 25–28].—Nat. Bureau of Standards. (*Journ. Applied Phys.*, Sept. 1944, Vol. 15, No. 9, p. 651.) For a list from MT 1 to MT 24 *see* back cover of *Journ. of Res. of Nat. Bureau of Stds.*, Aug. 1944, Vol. 33, No. 2.

631. "Navigational Trigonometry" [Book Review].—Rider & Hutchinson. (*Quart. Applied Math.* [Brown University], April 1944, Vol. 2, No. 1, pp. 91–92.) A very favourable review.

632. "Radio Technique" [Book Review].—Mills. (*Electrician*, 1st Dec. 1944, Vol. 133, No. 3470, p. 496.) "To present to students of radio engineering a complete yet concise collection of material not hitherto gathered together in one volume . . ." *See* also *Journ. of Scient. Instr.*, Nov. 1944, Vol. 21, No. 11, p. 203.

633. "Radio Technology" [Book Review].—Weller. (*Wireless Engineer*, Dec. 1944, Vol. 21, No. 255, p. 585.) A long and highly critical review of the book referred to in 3676 of 1944.

634. "Radio Receivers and Transmitters" [Book Review].—Amos & Kellaway. (*Electrician*, 1st Dec. 1944, Vol. 133, No. 3470, p. 496.) This is the book referred to in 3150 of 1944.

635. "Lexikon der Funktechnik und ihrer Grenzgebiete, unter besonderer Berücksichtigung der Rundfunktechnik" [Book Review].—Günther & Richter. (*T.F.T.*, March 1944, Vol. 33, No. 3, p. 57.)

636. "Electronics: Today and Tomorrow" [Book Review].—Mills. (*Bell S. Tech. Journ.*, July 1944, Vol. 23, No. 3, p. 334.)

637. The Invention of "Wireless" [Account of 1939/1943 Prosecution of Prof. Turpain by Branly's Heirs, for Omission of Any Reference to Branly's Work in an Article in *L'Almanach populaire*].—(*Génie Civil*, 1st Aug. 1943, Vol. 120, No. 15, p. 176.)

638. The Legend of Selden Hill [Story of the Pioneer U.S.W. Work of Ross Hull & His Colleagues of *QST*].—Read. (*QST*, Aug. 1944, Vol. 28, No. 8, pp. 46–49 and 76, 78.)

639. Automatic Relaying [Editorial prompted by Concession to A.T. & T: Sketch of Possible Automatic-Relay Scheme for Amateurs].—(*See* 586.)

640. After the War [Editorial on the Prospective Activities of the A.R.R.L. (Headquarters, Affiliated Clubs, *QST* Editorial Staff, etc.)].—(*QST*, Aug. 1944, Vol. 28, No. 8, pp. 7–8.)

Among the technical problems, "what about pulse technique? How to apply to ham operation some of the spectrum economy of new multiplexing methods? New conveniences in operating, panoramics and aperiodics and d.f., frequency meters of much greater precision. Ham gears for automatic relaying [*cf.* 639, above] . . . an amateur version of facsimile . . . Never, since the birth of amateur radio, has the outlook been so bright in technical interest for the ardent amateur . . . Meanwhile, of course, we all have something harder to do . . ."

641. War Surplus Disposal [Suggestion that Demobilised Wireless Technicians should be helped to Re-Equip Themselves with the Tools of Their Trade by being permitted to buy on Same Terms as a Dealer].—Cazaly. (*Wireless World*, Nov. 1944, Vol. 50, No. 11, p. 349.)

642. Monthly Commentary: A Place in the Ether [" Few Signs of Any Intense Official Activity in This Country, but in America Large-Scale Planning is Now Well under Way": Postscript to 2078 of 1944: Omission of Provision for International Long-Distance Broadcasting: etc.].—(*Wireless World*, Nov. 1944, Vol. 50, No. 11, p. 321.) *Cf.* Jett, 4011 of 1944.

643. World Radio Charter [Note on Hubert's Proposals for an "International Radio Charter"].—Hubert. (*Wireless World*, Nov. 1944, Vol. 50, No. 11, p. 327.) *See* also 3645 of 1944.

644. Proposal for the Organisation of a World Scientific Commission.—Kaempffert. (*Electronics*, May 1944, Vol. 17, No. 5, p. 91.)

The proposer, Science Editor of the *New York Times*, urges: "Give us international cooperation in science and soon there will be cooperation in other fields, with the result that science will contribute to lasting peace." The Editorial comment, while echoing the hope, illustrates the difficulty of such cooperation by citing the problems of getting even a very small group of people together on a very small matter (the deciding on a common set of symbols for the components of electrical and electronic circuits).

645. The U.S. Army Signal Corps [Message from Chief Signal Officer: "O.C.Sig.O": Signal Corps in the Field: in Engineering: in Combat].—(*QST*, Sept. 1944, Vol. 28, No. 9, pp. 7, 9–49, and 90..122.)

"An attempt to convey in one unified picture the structure, application, and conduct of military radio communications as found in combined ground-force operations . . ."

646. Hams and the Army Airways Communications System : Highlights and Sidelights.—De Soto. (*QST*, Aug. 1944, Vol. 28, No. 8, pp. 12–17 and 80..98.)

647. Progress of Broadcasting in India during Five Years of War [Note on Recent A.I.R. Report].—All-India Radio. (*Sci. & Culture* [Calcutta], Aug. 1944, Vol. 10, No. 2, pp. 80–81.)

648. The Reorganisation of French National Broadcasting [by Decree No. 994 of 7th Nov. 1942].—(*Génie Civil*, 15th Dec. 1942, Vol. 119, No. 27, p. 332.)

649. Science Education [for the Buying Public] Needed to meet the Coming "Automatic Age."—Breech. (*Scient. American*, Sept. 1944, Vol. 171, No. 3, p. 128.) From the president of the Bendix Aviation Corporation.

650. Establishment of a New Journal, *The Australian Journal of Instrument Technology.*—(*Journ. of Scient. Instr.*, Nov. 1944, Vol. 21, No. 11, p. 204.)

651. Comments on "Organisation of Physics in America" [3317 of 1944 : Protest against an Apparent Attempt to Define the Scope & to Circumscribe the Activities of the I.R.E : Inaccuracy of the Chart : etc.].—Goldsmith. (*Journ. Applied Phys.*, Sept. 1944, Vol. 15, No. 9, p. 649.) The writers of the paper reply on pp. 649–650.

652. The Work of the Joint Council of Professional Scientists.—(*Journ. of Scient. Instr.*, Nov. 1944, Vol. 21, No. 11, p. 204.)

653. An "Unterminated" Line [Incorrect Use of Word "Unterminated" to denote Open-Circuited or Open-Ended].—G. W. O. H. (*Wireless Engineer*, Dec. 1944, Vol. 21, No. 255, p. 559.)

654. Application of Microfilming to Condensing and Preserving Engineering Drawings and Other Industrial Material [Use of the "High-Fidelity Translite" System].—Microcopy Corporation. (*Scient. American*, Sept. 1944, Vol. 171, No. 3, p. 128.)

655. Special "Mars-Lumograph" Pencils for Pencil Tracings, giving the Same Clearness and Opacity as Indian Ink.—Staedtler Company. (*Génie Civil*, 1st Oct. 1943, Vol. 120, No. 19, p. 224.)

656. Automatic Timing of Exposures for Photographic Printing [Repetition Printing from Same Negative : a Condenser-Discharge Timing Device].—Townsend. (*Journ. Council Sci. & Indust. Res., Australia*, May 1944, Vol. 17, No. 2, pp. 127–129.)

657. A Proposed Spectral Sensitivity Index to describe Photographic Emulsions.—White. (*Journ. Franklin Inst.*, April 1944, Vol. 237, No. 4, pp. 289–299.)

658. Researches on Resolving Power, Grain, and Contrast, and on the Relations between Them, in Photographic Emulsions, *and* The [Statistical] Fluctuations of the Density of the Grains in Photographic Plates.—Fracastoro : Lovera. (*La Ricerca Scient.*, Nov. 1942, Vol. 13, No. 11, pp. 665–676 : pp. 677–682.)

659. Temperature and Degree of Ionisation of the Gas in Impulse Discharge [5–10 Microseconds : the Change in Spectrum of Krypton- & Argon-Filled Lamps].—Bogdanov & Wulfson. (*Comptes Rendus* (*Doklady*) *de l'Acad. des Sci. de l'URSS*, 10th Sept. 1943, Vol. 40, No. 7, pp. 263–266 : in English.)

660. Reflection Measurements on Rhodium Films in the Short-Wave Infra-Red Region [Investigation of the Greatly Varying Reflecting Power for Different Methods of Preparation].—Dühmke. (*Physik. Zeitschr.*, 15th Jan. 1943, Vol. 44, No. 1/2, pp. 10–17.)

661. Use of Bentonite in Fluid-Flow Analysis [by Polarised Light].—M.I.T. (*Sci. & Culture* [Calcutta], Aug. 1944, Vol. 10, No. 2, p. 85.)

662. Audible Reception of Keyed Light-Beam Signals, by Electronic Methods at the Receiver, eliminating the Mechanical "Chopper."—De Castro. (*QST*, Aug. 1944, Vol. 28, No. 8, p. 45.)

663. Visibility of Test-Objects under Low Illuminations [including Tests for Very Short Observation Times].—Gassovsky & others. (*Comptes Rendus* (*Doklady*) *de l'Acad. des Sci. de l'URSS*, 20th Aug. 1943, Vol. 40, No. 5, pp. 185–187 : in English.)

664. Dark Adaptation : Some Physical, Physiological, Clinical, and Aeromedical Considerations.—Sheard. (*Journ. Opt. Soc. Am.*, Aug. 1944, Vol. 34, No. 8, pp. 464–508 : with long bibliography.)

665. Current Problems of Visual Research [Variations in Visual Threshold : Visibility Curves under Different Conditions : Retina in a State of Change : Fundamental Response Curves].—Stiles. (*Proc. Phys. Soc.*, 1st Sept. 1944, Vol. 56, Part 5, No. 317, pp. 329–351 : Discussion pp. 351–356.) For an abridgment see *Nature*, 2nd Sept. 1944, Vol. 154, No. 3905, pp. 290–293.

666. Fluorescent Screens of High Resolving Power [*e.g.* for Ultra-Violet Spectroscopy].—Zelinsky. (*See* 548.)

667. Measuring Germicidal Energy [Use of Zinc-Silicate Phosphor for selecting the λ2537 Region : the Cadmium–Magnesium Phototube (3152 of 1935) : etc.].—Taylor. (*Gen. Elec. Review*, Oct. 1944, Vol. 47, No. 10, pp. 53–55.)

For a companion paper (by Luckiesh, Taylor, & Kerr) on measuring the transmission and absorption by water, *see* issue for September, No. 9, pp. 7–9. "One cannot view the extreme sensitivity of water to the transmission of energy at λ2537 without seeing some possibilities of a practical method of analysis . . ."

668. A PHOTOELECTRIC DEVICE FOR RECORDING VARIATIONS IN THE CONCENTRATION OF A COLOURED SOLUTION [Modifications of Previous Circuit, to suit Unskilled Operators].—Davenport. (*Journ. of Scient. Instr.*, Oct. 1944, Vol. 21, No. 10, p. 188.) From I.C.I. (Dyestuffs), Ltd.

669. ELECTRONIC SORTING [with Photocell & Partially Blacked-Out Cathode-Ray Tube].—(*Scient. American*, Aug. 1944, Vol. 171, No. 2, pp. 61–63.) For the possibility of mail sorting *see* bottom of p. 63.

670. SPECTROCHEMISTRY [at the Murray Hill Laboratory].—Jaycox. (*Bell Lab. Record*, June 1944, Vol. 22, No. 10, pp. 416–420.)

671. EXPERIMENTAL STUDY OF THE HETEROGENEITY OF AN ALLOY BY THE METHODS OF QUANTITATIVE SPECTROCHEMICAL ANALYSIS.—Girschig. (*Comptes Rendus* [Paris], 1st/29th March 1943, Vol. 216, No. 9/13, pp. 292–294.)

672. MICROANALYSIS BY MEANS OF ELECTRONS [Theory, Design, etc., of the Electron Microanalyser].—Hillier & Baker. (*See* 539.)

673. THE TESTING OF MOULDED PLASTIC OBJECTS BY X-RAYS.—Guinier. (*See* 573.)

674. X-RAY MONOCHROMATISATION BY FOUR BALANCED FILTERS [surmounting Limitation of Ross's Balanced-Filter Method].—Kirkpatrick & Chang. (*Phys. Review*, 1st/15th Sept. 1944, Vol. 66, No. 5/6, p. 159: summary only.) For Kratky's differential-filter method *see* 349 of January.

675. RADIOGRAPHY OF EXPLOSION AND DETONATION PROCESSES ["Microsecond Radiography"].—Zuckerman. (*Comptes Rendus (Doklady) de l'Acad. des Sci. de l'URSS*, 10th Sept. 1943, Vol. 40, No. 7, pp. 267–270: in English.)

676. FUNDAMENTAL CRITERIA FOR THE CONSTRUCTION OF AN ACOUSTICALLY AND ELECTRICALLY SCREENED ROOM FOR PHYSIOLOGICAL AND PSYCHOLOGICAL RESEARCH, AND THE RESULTS OBTAINED.—Gemelli. (*La Ricerca Scient.*, Nov. 1942, Vol. 13, No. 11, pp. 619–627.)

677. THE ELECTROFLUOROSCOPE AND ITS APPLICATIONS [primarily in Biological Research].—Minot. (*See* 538.)

678. RADIO-FREQUENCY DIELECTRIC PROPERTIES OF A CELLULOSIC SYSTEM AT LOW MOISTURE CONTENTS [in connection with Study of Moisture-Testing by R.F. Methods: Measurements on Dehydrated Carrots: Theory of the Properties observed].—Dunlap & Makower. (*Phys. Review*, 1st/15th Sept. 1944, Vol. 66, No. 5/6, p. 159: summary only.)

679. VACUUM-TUBE RADIO-FREQUENCY GENERATOR CHARACTERISTICS AND APPLICATION TO INDUCTION HEATING.—Kinn. (*Elec. Engineering*, Aug. 1944, Vol. 63, No. 8, p. 314: summary only.)

680. RESISTIVE COUPLINGS OF INDUCTIVE COILS USED IN ELECTRICAL PROSPECTING OF THE SUBSOIL [General Theory (hitherto lacking) leading to an Examination of Secondary, Parasitic Effects and the Choice of a Highly Sensitive Circuit which is Simple in Operation].—Belluigi. (*La Ricerca Scient.*, Dec. 1942, Vol. 13, No. 12, pp. 770–772.)

681. ELECTRICAL CHARGES PRODUCED BY FLOWING GASOLENE [Measurements, by Special Thermionic Meter, show Currents from 10^{-7} to 10^{-8} Ampere with Normal Rate in Filling Tank Trucks].—Mackeown & Wouk. (*Journ. Franklin Inst.*, Sept. 1944, Vol. 234, No. 3, pp. 301–302: summary, from *Indust. & Eng. Chem.*, Vol. 34.) *See* also 2711 of 1943.

682. GEOMAGNETIC [and Man-Made Magnetic] INFLUENCES ON A KUHLMANN BALANCE.—Corwin. (*Terr. Mag. & Atmos. Elec.*, Sept. 1944, Vol. 49, No. 3, p. 211.)

683. ELECTRONIC CIRCUIT DESIGN [Three Steps, All affected by Normal Tolerances of Parts].—Ingram. (*See* 533.)

684. SOME APPLICATIONS OF ELECTRONICS [Paper to Association of Supervising Electrical Engineers].—Henderson. (*Electrician*, 17th Nov. 1944, Vol. 133, No. 3468, p. 450: short summary only.)

685. ELECTRONIC COUNTING [Newly Developed Counter Decade (Binary-Progression System) makes possible Accurate Counting at Rates up to a Million Objects per Second, surpassing Mechanical & Electromagnetic Counters in Accuracy & Versatility: for Photoelectric & Other Pick-Up Systems].—Potter. (*Scient. American*, Sept. 1944, Vol. 171, No. 3, pp. 106–108.)

686. ELECTRONIC METHOD FOR CONSERVING PAINT IN SPRAYING OF METAL SHELLS OF VALVES [Time Constant so arranged that Spray is interrupted only if Two or More Shells are missing on Conveyor].—R.C.A. (*Journ. Applied Phys.*, Aug. 1944, Vol. 15, No. 8, p. 628: paragraph only.)

687. PAPERS ON SUPERSONIC INSPECTION METHODS [for Rapid Detection of Cracks, Differences in Hardness, Changes in Dimensions, & Variations in Composition], AND OTHER APPLICATIONS OF SUPERSONICS.—Andrews & others. (*See* 510/12.)

688. CAPACITOR-DISCHARGE WELDING SYSTEMS.—Klemperer. (*Electronics*, May 1944, Vol. 17, No. 5, pp. 118–121.)

"Voltage, current, and time relations for the successive phases in capacitor-discharge welding are developed for shunt and inverse tube circuits, and a quick method is given for determining whether undesirable saturation exists in the welding transformer."

689. Electronic Turbo Regulator for Multi-Engine Airplanes. — Gille & Sparrow. (*Electronics*, May 1944, Vol. 17, No. 5, pp. 108–112.)

"Speed of turbo-supercharger for each engine is automatically regulated through a four-tube electronic circuit to provide a constant engine power condition at any altitude within operating limits, thus allowing the pilot to concentrate on flying the airplane": "today flying in many of our largest bombers."

690. Applications of Electronics to Aircraft Flight Control [System of the C-1 Autopilot for Precision Flight Control in Bombing].—Gille & Kutzler. (*Elec. Engineering*, Aug. 1944, Vol. 63, No. 8, p. 314: summary only.)

691. A Theory of Servo-Mechanisms with D.C. Shunt Motor Feed from an Ionic Rectifier.—Nikitin & Kunitzki. (*Comptes Rendus (Doklady) de l'Acad. des Sci. de l'URSS*, 30th July 1943, Vol. 40, No. 3, pp. 98–101: in English.)

692. Rational Limitation of the Use of Electronic Control ["a Simple Gear System or Any Other Simple System is Always Preferable to a Complicated System, Electronic or Not"].—Weiller. (*Electronics*, May 1944, Vol. 17, No. 5, p. 91.) With special reference to variations between valve and valve and component and component —"rubber teeth".

693. Electronic Regulator for Arc Furnaces [in Production of Alloy Steel: Electrode-Position Control]. — Reilly & Valentine. (*Elec. Engineering*, Aug. 1944, Vol. 63, No. 8, Transactions pp. 601–604.)

694. Electronic Thermometer [utilises Resistance Coefficient of Organic Liquid: Advantages include Much Smaller Lag and Remote Indication].—Kollsman Instrument Division, Square D Company. (*Scient. American*, Sept. 1944, Vol. 171, No. 3, p. 108.)

695. The Calibration of the Electromagnetic Microbarograph [at the University of Pittsburgh].—Sulkowski. (*Journ. Franklin Inst.*, March 1943, Vol. 235, No. 3, pp. 239–258.)

696. Pressure and Vibration Indicators using a Cathode-Ray Oscillograph [Survey].—d'Aboville. (*Génie Civil*, 15th Aug. 1943, Vol. 120, No. 16, p. 190: summary only.)

Among the types considered are those depending on photoemission (variable distance between anode and photoemissive cathode) and on capacitance-change (Philips Company).

697. Modern Measuring Methods for Non-Electric Quantities [Force, Pressure, Extension, etc: Survey, with 93 Literature References].—Hermann. (*E.T.Z.*, 1st July 1943, Vol. 64, No. 25/26, pp. 349–354.)

698. The Construction of Apparatus for Observation and Measurement.—Chevenard. (*See* 530.)

699. Carrier Telegraph Systems.—Bramhall. (*Elec. Engineering*, Aug. 1944, Vol. 63, No. 8, pp. 283–286.)

"Since the invention of the telegraph a century ago, refinements have been made until as many as 144 automatic printers operate at 60 words per minute over a pair of lines. Some of the steps in this evolution are reviewed in this article." The advantages of frequency modulation are shown.

700. A New Carrier Relaying System [One-to-Three-Cycle System combining Simplicity of Pilot-Wire Protection with Versatility of Power-Line Carrier]. — Halman & others. (*Elec. Engineering*, Aug. 1944, Vol. 63, No. 8, Transactions pp. 568–572.)

701. A Versatile Power-Line-Carrier System. —Lensner & Singel. (*Elec. Engineering*, March 1944, Vol. 63, No. 3, Transactions pp. 129–133: Discussion in *Supp. to Elec. Engineering, Transactions Section*, June 1944, Vol. 63, pp. 437–439.)

702. The MHO-Carrier Relaying Scheme: a Simplified Carrier Scheme for Long or Heavily Loaded Transmission Lines. —Cordray & Warrington. (*Elec. Engineering*, May 1944, Vol. 63, No. 5, Transactions pp. 228–235: Discussion in *Supp. to Elec. Engineering, Transactions Section*, June 1944, Vol. 163, pp. 434–436.)

ABSTRACTS AND REFERENCES INDEX.

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